FLIGHT
and
The AIRCRAFT ENGINEER

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The Outlook

Hundred Octane

THE article *Fighter Station* in this issue contains a significant reference to the use of fuel of 100-octane number by our fighters. Precise figures for the increase in performance attained are not immediately available, but it may be said that in an emergency the Merlin engines as used in the Spitfires and Hurricanes can be boosted to a pressure of 12lb.

It is also permissible to state that with its two-speed supercharger in high gear and operating on 100-octane fuel the Merlin R.M.2S.M. engine has a maximum output at 16,750ft. of 1,145 h.p. The effect of the forward-facing air intake will raise considerably the height for maximum speed.

Like other nations, America has for some time past used 100-octane fuel in limited quantities for her military aircraft. Lately she has adopted it as a standard, and we may refer to the performance figures for the Republic single-seater of the type used by the U.S. Army Air Corps. The top speed is increased by five m.p.h. (to 315 m.p.h.); the maximum rate of climb is 3,150 ft./min. instead of 2,950 ft./min., and the ceiling is raised from 29,500ft. to 31,500ft. These increases do not represent such improvements as are claimed for a Continental machine with a Bristol Mercury XV. Using 100-octane fuel the top speed is 260 m.p.h. at 17,300ft. whereas with "87" it was 236 m.p.h. at 15,700ft. The rate of climb to 19,500ft. is reduced by four minutes.

The immense improvement in the range of the Bristol Blenheim can be attributed directly to the use of 100-octane fuel which permits take-off at a much higher all-up weight. Actually the Mercury now gives 1,050 h.p. for take-off, compared with 830 h.p.

Whatever the gains which accrue from the use of the new fuel in our Spitfires, Hurricanes and Defiants, it is certain that they now have an even better chance of catching and shooting down raiders.

Exchange of Personnel

A FACILITY which has existed for many years in the educational sphere might well be applied to aeronautical activities within the Empire. It has long been a custom for teachers of all grades and university lecturers in the Dominions and Colonies who seek overseas experience to arrange an exchange with an "opposite number" in the United Kingdom. After approval by their respective authorities the two exchange posts for a definite period, usually a year, and do each other's work.

Innumerable examples of this exchanging are available, and in all cases the results have been most beneficial to all concerned. The teachers have their technical and general horizons extended; their students benefit by receiving instruction from persons who have some knowledge of countries other than their own; and the teaching authorities benefit by the rise in qualifications and experience of their staffs after the exchange is completed.

The aeronautical industry is now being actively and permanently established in Canada and Australia, and strong bodies of technical men are being gathered together. There is no need to enlarge upon the advantages of exchange jobs for such men. The value of interchange of technical ideas and contact with people of other parts of the Empire is self-evident and will be seen to the full in the peace which will have to be won when this war is over. It is unlikely that any exchanges could be brought about during wartime, but our reason for bringing the idea up at this stage is that such things take considerable time to arrange and must be got under way now to take effect after the war. The establishment of such a scheme would be aided if those people desiring to exchange made their wishes known to those in authority above them.

think that the exchange system can be applied

with great advantage both as between private firms and as between government departments charged with research and administration. It is for those who agree with this idea to take the next step and seek to arrange their exchange.

Lockheed v. England

THE announcement elsewhere in this issue that sixteen Lockheed Lodestars have been ordered for South African Airways is a severe blow to the aircraft industry of England; so severe that it may be described as the loss of the South African market.

Events there are going the same way as they did in Australia. Before the ban on American aircraft was lifted and the first Douglas DC2 was imported in May, 1936, DH 86s and Rapides were in use on the airlines in Australia. But thereafter, Australian operators, except for a negligible number of Rapides, bought only American all-metal transports, Douglases and Lockheeds. They could not buy British because there was no comparable type.

Canada, too, when it went seriously into the airline business, equipped its new Trans-Canada Airlines with fifteen Lockheed 14s, and in New Zealand, though numerically few, Lockheeds make up a large proportion of the small transport fleet there. Now, with the total cessation of export since the war, we have clinched the Lockheed grip on our own markets, and the loss of South Africa swells the total to four—*the transport aircraft markets of all the British Dominions are now lost to the British aircraft manufacturing industry.*

One may, perhaps, be justified in asking if all is well commercially with the Empire when it cannot—no, will not—supply the needs of its own Dominions. None of these markets will be regained before the aircraft bought have worn out or otherwise reached the end of their lives. They will not be regained then without strenuous effort, for airline operators do not like changing over to a new design. For operating and maintenance reasons it is easier to go on with the same type, and if that type is satisfactory, an intruder has no chance. British airliners are now no more than intruders on the airlines of the British Dominions, and the result of the contest, Lockheed v. England, can be announced.

Sylt

IT is at least a possibility that the German pilots who killed a civilian and wounded several others in a village in the Orkneys did not do so deliberately; but the R.A.F. determined to impress on them that they must be more careful where they unload their bombs, even if they are in a hurry. But, in teaching that lesson, our airmen were careful not to hurt any German civilians. The Island of Sylt had been evacuated by civilians some time ago, and everything on it was therefore a legitimate target. So Hörnum was duly plastered, and the Germans have been careful not to let American correspondents wander there at will.

PRACTICE INTERCEPTION: Supermarine Spitfire eight-gun fighters of a squadron stationed in Scotland get off the mark for a practice interception. A visit to the squadron, which has made sixteen interceptions of enemy aircraft, bringing down nine machines, is described on pages 290-293.

WAR in the AIR

R.A.F. Raid Hornum Air Base

"Flight" photograph.

Ready to "bomb up." A Vickers Wellington with bomb doors open awaiting the armourer's party.

THE attempt by the German propaganda department to turn the Scapa Flow raid by fourteen machines into an attack of major importance resulted in the Royal Air Force returning the compliment by carrying out a bombardment of the German air base at Hornum, on the Island of Sylt, in the Heligoland Bight.

Three short bulletins were issued by the Air Ministry. The first, during the evening of March 19, said:

"To-night the Royal Air Force attacked and severely damaged the German air base at Hornum, on the Island of Sylt. This is one of the shore bases from which German aircraft operate against our naval forces and merchant shipping. This action follows the attack upon our shore bases in the Orkneys."

The second, which was made public at 4 a.m. on the following morning, was issued while the operation was still proceeding, and stated:

"The attack by aircraft of the Bomber Command upon the Hornum air base, on the Island of Sylt, which started at about 8 p.m. yesterday evening was still in progress at 3 a.m. this morning.

"The first aircraft to take part have already returned in safety and captains report accurate bombing of the objective. Some searchlight and anti-aircraft gun opposition was encountered."

The third and last bulletin, at 7.45 a.m., summed up the situation with:

"The attacks made on Hornum last night were spread over a period of about seven hours.

"All our aircraft have returned safely with the exception of one which is overdue and must be presumed to have been lost.

"The information now available shows that the damage reported earlier is very extensive and includes direct hits on slipways and hangars."

The raid was carried out by some 49 machines which attacked singly in relays and maintained almost a continuous assault on the target. Some 45 tons of bombs—an assortment of 500 lb. and 250 lb.—were dropped, and direct hits on slipways, hangars and barracks were observed. The night was fine with good visibility and the first crews were able to identify their targets by the light of a brilliant moon; for those who came later the fires caused by the earlier bombs were ample indication. It is strange that yet once more our machines have been able to carry out a lengthy operation such as this and meet with practically no opposition from enemy fighters. Only one crew reported an attack by an enemy fighter and this was driven off by the rear gunner. Of ground defences, however, there were plenty, and it is surprising that a greater toll was not taken of our aircraft for, according to the crews concerned, some of them came as low as 1,000 feet to unload their bombs, whilst the highest was only 8,000 feet.

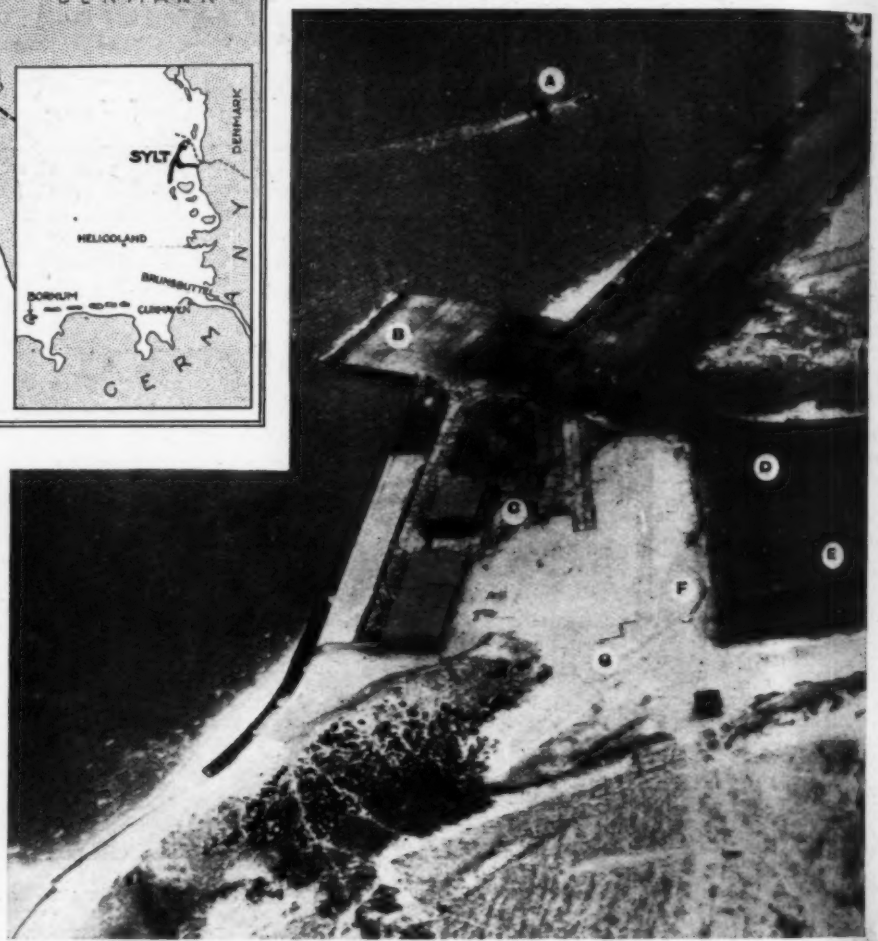
Round the seaplane base itself a semi-circle of searchlights came into action as our aircraft approached and anti-aircraft batteries in many parts of the island put up a heavy barrage. In the earlier phases of the attack intense fire was experienced from light anti-aircraft guns by those machines which attacked from a low height.

The last British raider to leave the scene of operations arrived at its base in England at 5.30 a.m. One bomber did not return and, according to Danish witnesses, this was shot down by the ground defences and fell in the sea.

WAR IN THE AIR (CONTINUED)

(Above) A map of the Island of Sylt which was extensively raided by the R.A.F. on the night of March 19-20.

(Right) Hornum seaplane base on the south of Sylt Island before the raid.



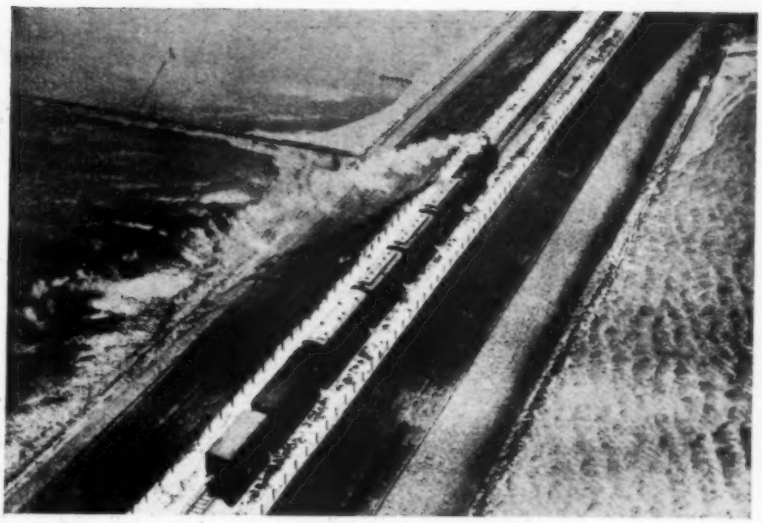
A. Heinkel HE115 being towed to crane for lifting out. B. Slipway for launching. C. Curious camouflage effect. D. Dolf flying boat. E. Large hangar. F. Disused light railway. G. Shelter trench.

The average length of flight from take-off to landing was about five hours each, and many of the members of the crews reported direct hits and extensive fires as a result of the bombardment.

One pilot who started out round about midnight said: "We flew over to Sylt and approached at a height of about 1,500ft. We flew round and identified the targets and then dived to 1,000ft. over them. My second pilot, who acted as bomb-aimer, directed me on the target and we had just flown over it when suddenly I heard a shout from behind—"We have hit them." Another pilot who had spent a busy quarter of an hour over Hornum remarked: "We were being closely followed by a trail of pom-pom shells. At one stage they came too close for comfort. Our first bomb hit the ground near a slipway and three others, according to a pilot of a machine which was close behind, registered direct hits on a hangar."

The estimated damage caused by the raid is very considerable. It includes the complete destruction of an aerodrome petrol dump, complete destruction of two large flying boat and seaplane hangars at the north of the island, partial destruction of coastal and anti-aircraft

A Heinkel HE115 seaplane being lifted out of the water at Hornum. The HE115 is used for convoy raiding and magnetic mine laying.



The light railway on the Hindenburg Dam. Strangely enough, this railway is British owned.

batteries on the north coast and an anti-aircraft tower on the Hindenburg Dam. It seems certain that very considerable damage has also been done to the dam itself and this may prove to be more important than any of the other hits as it is a light railway along this dam which carries all the supplies to the island.

Almost coincident with the arrival home of the last bomber two aircraft were despatched to the scene of operations to view the extent of the damage done. Two Messerschmitt Me109s put in an appearance but failed to intercept our machines.

For the first time in the history of all our wars the Prime Minister was able to announce, during a debate in the House of Commons, the progress of the action, and on the next day Sir Kingsley Wood, the Air Minister, made the following statement:

During the week the customary "Security Patrols" have been maintained and leaflet raids as far east as Poland have been carried out.

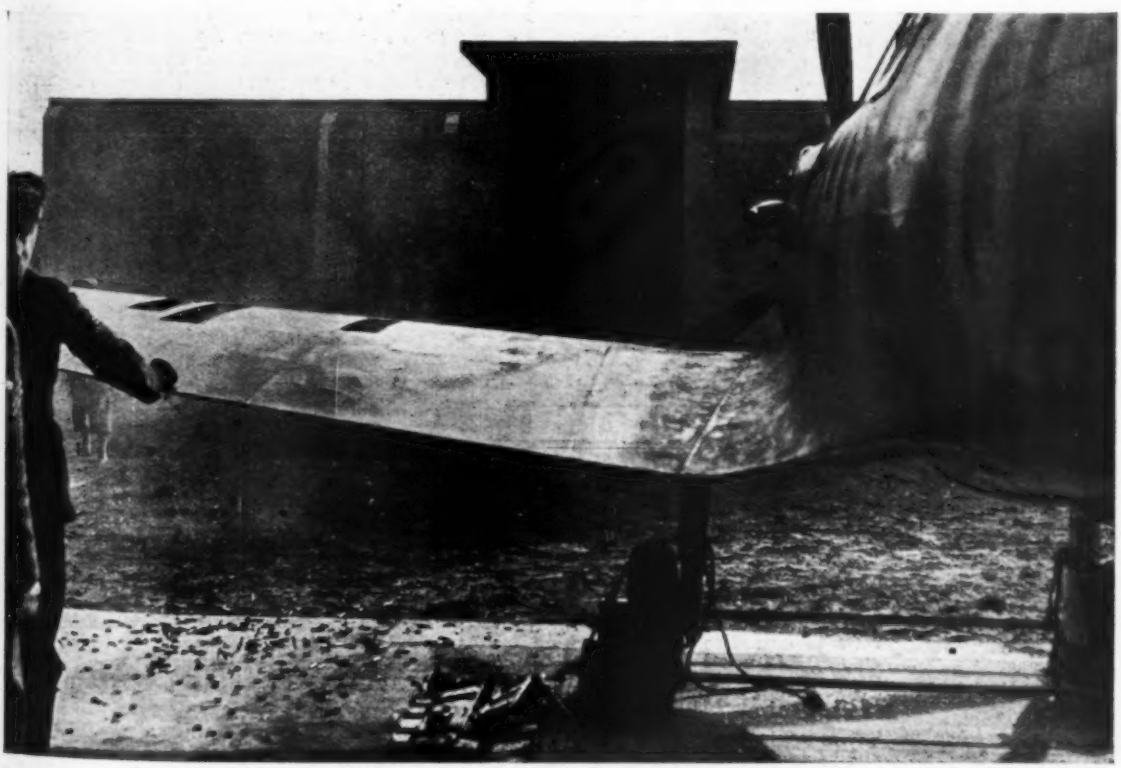
On the night of March 19 a considerable number of German aircraft took part in an attack on a British shipping convoy off the Scottish coast.

The Admiralty communique read: "Attacks were made this evening by enemy aircraft on a convoy off the Scottish coast. Enemy aircraft were engaged by escorting warships. Patrols of the Fleet Air Arm and Coastal Command were active. On one occasion two Fleet Air Arm aircraft attacked and dispersed 10 Heinkels.

"The enemy have claimed that several ships have either been sunk or have suffered serious damage. The fact is that no damage or casualties were incurred by H.M. ships or aircraft. Two small neutral vessels, however, received minor damage."

It is understood that the neutral ships damaged were one Norwegian and one Swedish.

Photographs from Denmark of a German machine which failed to get home make it evident that the much vaunted Junkers Ju 88s were used for the Scapa Flow raid.



A Spitfire of a Scottish squadron tries out its port guns at the stop butts. The noise is shattering and the empty cases and links pour from apertures in the wing.

Topics of the Day

THIS A.T.A.

More About a Somewhat Misunderstood Body of Pilots : One Way of Doing a Job of Work

ANY person who may have read all the articles, varying from brief facts to unmitigated balderdash (in large headlines), which have been written from time to time about the Air Transport Auxiliary can be forgiven if he or she has some very queer ideas about the scope and purpose of this organisation.

Students of the more earnest broadsheets possibly know something about it, though even they, if they think about it at all, carry a mental picture of a bunch of ancient crocks somehow contriving to ferry military aeroplanes about the countryside and helped by a few women pilots who fly the trainers. Readers of the picture papers can only think that the A.T.A. is exclusively peopled by lady aviators who rush desperately about (in the intervals of being photographed) in our latest fighters and bombers—to the embarrassment of duty pilots and others at Service stations.

Let me endeavour, once again, to give the facts. For some time before the war the British Airways part of B.O.A.C. realised that if this country was seriously raided, a lot of aeroplanes and pilots would be required to maintain essential communications. They also realised that there were a great many good and experienced pilots for whom the Air Ministry had no use. (This was before the R.A.F.V.R. "twenty-eight to forty-eight scheme" had been instituted). A number of amateur private owners, ex-Service and ex-airline pilots were therefore circularised and provisionally signed on as lower-grade first and second officers according to their experience.

The war arrived, but no bombs, and no communication work for them to do. Somebody then had the brilliant idea that this group of picked and tested pilots *might* be found suitable to act as ferry pilots. A number were therefore sent to the Central Flying School in order to discover whether they could cope with modern military types, and a few experimentally retained for a quick conversion course. They were duly converted, without difficulty, in a matter of six flying hours or so, and others were afterwards sent to this centre of all that is best in Service flying to be graded according to their several abilities.

Man's Estate

Just as soon as a sufficient number of "trained" A.T.A. pilots were available, groups were attached to the two Service ferry pools and these groups worked happily and with reasonable satisfaction alongside the Service pilots for a matter of four and a half months, after which they were considered to be sufficiently experienced to be allowed to operate a ferry pool of their own. This is now in action, but every one of us knows that without the Service experience, and the advice and help of those experts in all-type ferry flying, the R.A.F. pilots, we should not have been able to do it.

Meanwhile, the powers-that-be decided that the experience of women pilots should not be wasted, and a group of picked ones were enrolled in the A.T.A. and attached to a certain factory for the ferrying of trainers. Let it be said at once that whatever queer feelings of jealousy there may be in various quarters, these pilots are good. Most of them were professionals before the war and deserved something better than a purely ground job, for instance, in the W.A.A.F. The time may come when every male pilot will be needed for active service and, since this is total war, there is no room for pride.

But, for the moment at any rate, the women are only flying trainer types and there is no immediate possibility that they will be asked to fly Spitfires and Wellingtons. On the score alone of mechanical knowledge and sheer physical strength, I doubt whether they would be able to cope with such devices. That remains to be seen.

To touch on an unfortunate subject, a good deal of nonsense has been written and spoken about the salaries paid to the A.T.A. pilots. Figures in black and white mean very little and it is enough to say that the first officers receive, altogether, about as much as a flight lieutenant in the R.A.F., while a second officer's pay is about the same as that of a flying officer. *And* there are no allowances except that normally given for "subsistence" while away from the base—neither marriage nor any other kind.

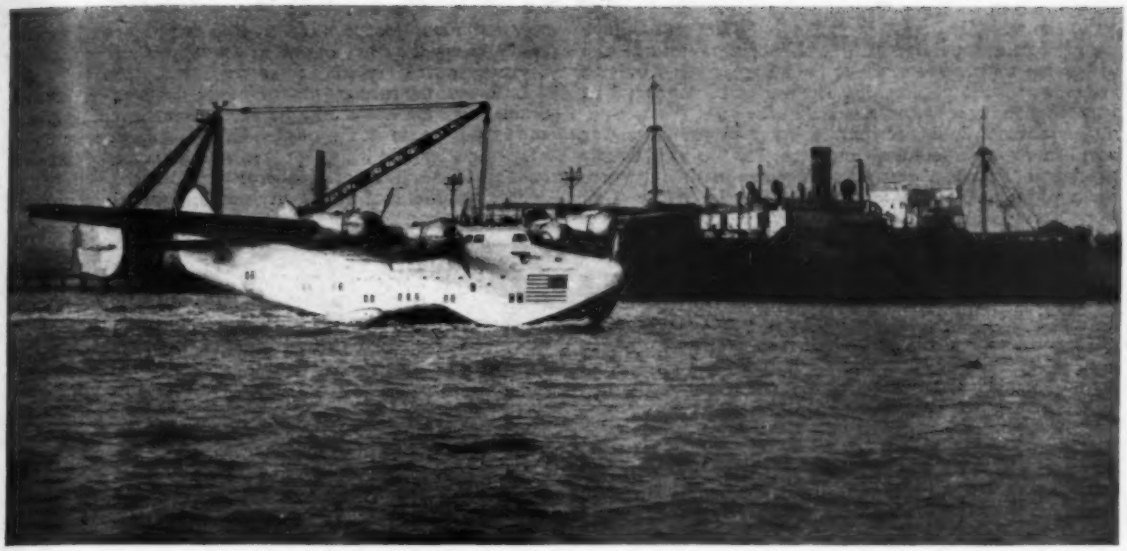
Long Experience

Most of the A.T.A. pilots are over thirty-five years of age and would, if they had made the Service a career, at least have reached the rank of squadron leader. The majority, too, have had a much greater flying experience than is obtained by a short service officer during his five years, and, except in the case of ex-Service pilots, they have paid in hard cash for their training and subsequent flying. In the circumstances, the comparison does not seem to me to be overbearingly in favour of the A.T.A. pilots. In fact, the only real complaint made by Service pilots is that we are actually doing a job we like. To many, such a situation in wartime is unforgivable; before one should be paid for anything it is apparently necessary to be a square peg in a round hole.

But, on the whole, we get on very well with the Service. When, as happens very occasionally, we find it difficult to remain patient while being obstructed by medium-placed officers ten years younger than ourselves and with about half our flying experience, we just remember that lots of others are *forced* to be patient in such circumstances and are not being so merely because it is more polite.

Finally, for the benefit of those who ask why we're not in the R.A.F., it can be said that without the A.T.A. the majority of us would be plodding about in ground jobs. The Service medical board must have a standard, even for non-operational flying, which will cover the selected personnel for all possible work, and not more, perhaps, than ten per cent. of the A.T.A. pilots would pass this board. For one unimportant reason or another the majority would be told that they were unfit to fly modern military types, though they might be permitted to waste their time giving elementary instruction. Nobody will ever believe, for instance, that it is possible to fly aeroplanes while wearing spectacles, just as it is possible to eat while wearing false teeth. And it is not even entirely necessary to be able to distinguish reliably between dirty red and green flags, to be able to hear a pin drop three rooms away, or to be able to stand on one leg with one's eyes closed. The flying of modern types requires intelligence and calm judgment far more than physical perfection.

INDICATOR.



The *Yankee Clipper*, inbound from Europe, taxis past the American freighter *City of Flint*, docked at Baltimore after its recent famous voyage during which it was captured by a German warship and freed by Norway.

COMMERCIAL AVIATION

THOSE in charge of the good ship "Civil Aviation" look extremely jolly on deck in their white duck pants and their little yacht hats set at the exact angle approved by Mr. Lincoln and warmly seconded by Mr. Bennet. Each cap, by the way, has a small round hole in front, and the peak acts as an alighting board for the bees which, just at the moment, appear to be swarming.

Most of the rather over-numerous Captains of the ship stand tense at the helm, tugging in opposite directions and yelling contradictory orders down the engine room speaking tube. This might lead to confusion but for the fact that the helm is not coupled up to the rudder but to a ventilator in the saloon where the three Commissars who really rule the ship sprawl at their ease. They are clad in the most decorative uniforms of the three fighting services and their hats are solid brass superimposed upon heads of solid ivory.

As for the engine room speaking tube, it has a sock in one end and a cork in the other, and anyway the stokers have all gone to their tea and the boilers are cold but otherwise everything in the garden is lovely.

But the garden is on a lee shore towards which the good ship Civil Aviation is drifting with a celerity unusual in Civil Aviation affairs, so that neither horticulturally nor nautically is any particular progress being made.

Bodies of Experts

Meanwhile the Captains and the Kings on deck twiddle the tiller and cast eagle glances to larboard, to starboard and especially aloft where the sun rapidly climbs to its appointed position in relation to the yardarm. The representatives of the Operating Companies, battened down under hatches in four foot of bilge water, await the wreck of the ship, confident that they will not only be drowned but court martialled as well for losing it and that, I think, is a fair if slightly allegorical estimate of the position.

Maybe I am wrong and perhaps a tremendously forceful and progressive drive in civil aviation is to be expected. There is, for example, to be a sequestered, cobwebbed retiring room somewhere, I understand, with "Hush, Silence and Do not Disturb" on the door. Within will drowse an Advisory Committee to "Keep under review the position of civil aviation" in the light (considerably dimmed) of the present situation and to plan for the future. In an inner room heavily padded and decorated with drowsy poppies "a small body of experts will keep in close touch with technical development in the field of civil aviation abroad."

But When?

And what is our experience of Advisory Committees, chaps, and worse still, of small bodies of experts?

Expert 1: "What's all this about variable pitch props abroad, George?"

Expert 2: "Never heard of them, old man. I'm busy turning down some revolutionary idea some foreign fella's got hold of, to substitute metal props for wooden ones. Horrible idea, I mean to say. What?"

And so (yawn) it will go on, (snore) believe me.

Meanwhile, just to show that there is untiring progress and unceasing watchfulness of the interests of civil aviation, a perfectly amazing statement which was not, as it should have been, greeted with roars of merriment, was made in the House of Commons a few days back, in answer to a question.

"Air liners of the *Heracles* class employed on the Empire Air Services are to be replaced by more up-to-date aircraft as soon as these can be made available."

Not a smile from the House, which has heard much the same lamentable story three or four times within the past four or five years, only in those days it was proposed to withdraw this class of aeroplane, even from the shorter European services as a type which had done magnificent work in its day but was now obsolete.

All things considered this announcement in Parliament is roughly equivalent to an announcement to-day in that place, that it has been decided to withdraw Stevenson's Rocket from the London-Glasgow run as soon as more up-to-date engines are available.

Now about the availability of aircraft, the lack of which has apparently forced Imperials to employ the reliable but

slightly tardy Heracles type on Empire routes, there should be absolutely no lack of up-to-date aeroplanes. Large numbers of commercial aircraft, such as the "Flamingos" have been collared and painted N.A.C. club colours (sewage and sage green) and spend most of their time stabled outside the H.Q. of some pettifogging Brass Hat in command of Army Teapot Spouts, Replacements of.

Other aircraft have been strategically placed since war started in remote spots and forgotten, for the very simple reason that there is a vast and expensive map somewhere with a vague and expensive young officer in charge of it. Every aircraft likely to be useful for air line work has a corresponding pin on the map, and when the charwoman flicks her duster, chaos supervenes.

There is a rather more than semi-authentic story of a pilot and crew with a fast, expensive and brand-new latest-type air liner, being placed at Strikeme-sub-Konshus when war started and definitely overlooked for four or five months. The pilot then rang O.C. map, who informed him that he did not exist, there was no such aeroplane as his, and that, according to the map, Strikeme-sub-Konshus was a creek in the north of England and not an aerodrome.

So sure was the laddie in charge of the map that the pilot began to feel like the driver of the ghost train, and went off and drank a pint of far from wraith-like ale, accompanied by the sort of solid beef steak no ghost could stomach.

Then there was the little Civil Servant with his nightie and bed socks in a satchel, who had to travel on phenomenally important national service from somewhere in Scotland to somewhere in the remote west. To him was allocated a "Flamingo" which happened to be on the spot, but O.C. map brushed that particular flag off with his ear in passing, so at dawn next day he sent another Flamingo from the west to fetch the little man, and ultimately the journey was made by two Flamingos, in one of which sat the little bloke, whilst the other carried his nightie. Complete uniformed crews with great air line experience flew the two planes, and the C.S. is rumoured to have lodged a complaint afterwards that he really should have had an R.A.F. escort as well.

Stories, too, are told of some wizard departmental economist who urged civil servants to spend less on letter writing and save stationery and stamps by making more use of the fleet of aeroplanes of N.A.C., so that small officials now make long journeys by air, stop overnight and explain to the bloke they have gone to see why their department never answered "yours of the 10 March, 1820."

Lashings of money thus disappear down fathomless drains, and the cynic may be excused for grinning grimly at the passionate desire of the Air Ministry to save a few thousands by throttling the life out of some of the few efficient internal air line concerns which exist.

It is notable, too, that if any pogrom, putsch or purge is suggested, these little fellows display an energy, determination and a swiftness of action which forms a delightful contrast to their usual furred colon, furred tongue, and furry-footed inactivity.

Somebody had studied the methods of Stalin fairly thoroughly on this occasion. The smaller firms in peacetime had showed an energy and initiative wholly inconsistent with civil service slumber, and they were, therefore, unpopular. How different from Comrades Railhead, Pullman, Sleeper and Buffer, who loathed aerial progress, never wanted anything startling, and always had a bottle of vodka and a bowl of caviare handy for a pal.

Came the war, distracting men's minds from small matters like justice and fair treatment for the small man, and the Commissars pounced.

Subtly, an interview was promised with the Big Chief, but simultaneously the local Gestapo requisitioned the property of the small firms who, in these new and totalitarian times, were lucky to escape being shot against a wall, previously whitewashed at their own expense.

The purge was hurried along so that it was a *fait accompli* before a single voice could be raised in Parliament, for dead men are thought to tell no tales.

But I misdoubt me if we have heard the last of it, and even the most unscrupulous liquidators have themselves suffered liquidation before now.

The Department for Supply of Raw Material for Raw Deals should watch its stealthy step.

Meanwhile I believe D.L.H., the Germany company, is steadily expanding internal air routes within Germany, and incidentally announces a newspaper freight and mail service between Berlin and Amsterdam. A. VIATOR.

CIVIL AVIATION IN INDIA

THE annual report by the Director of Civil Aviation in India has been published for the year 1938-39. It indicates that, up to the outbreak of war, civil aviation was undergoing the same vigorous expansion in that country that it has everywhere else. On the Empire system Imperial Airways and its associated companies flew approximately 7,000,000 aeroplane-miles and carried 12,392,000 ton-miles of total loading. Corresponding figures for the previous year were 4,300,000 and 6,315,000.

The weight of mails carried to and from India exceeded the estimate by 18 per cent., the total weight transported being 460 tons. Passenger traffic to and from India also showed a big increase from 1890 to 2,651, and freight has increased from 35.6 to 86.6 tons.

The amount of flying done by the flying clubs decreased slightly from 13,400 hours to 12,500. The reason for this is not given, but it is conjectured that sufficient support has not been given by the Government, as it is stated that arrangements are now being made to lend Tiger Moths to the clubs. Government help to enable the clubs to use Tiger Moths was given several years ago in Australia. (Later information on club flying since the war indicates that it has increased enormously.)

New wireless equipment is being installed on the trans-India and South India routes. A chain of short-wave stations on the trans-India route will be used when completed for inter-communication between stations, thus freeing the medium-wave stations for communication with aircraft. Aerodrome work is also required, as existing landing grounds are becoming inadequate in size for the aircraft in use, and considerable capital expenditure will be involved.

An excellent safety record is quoted. During the last four years no passengers have been injured in the 5,500,000 aero-plane-miles flown by Indian commercial aircraft, while in the last three years the 7,250,000 aeroplane-miles flown by commercial and other civil machines have involved no instance of failure of the airframe.

Activity in Japan

IT is reported that Japanese aircraft manufacturers are receiving enquiries which may lead to the export of civil aircraft and it is said that sales of military types have already been made abroad These enquiries are due to the inability of many European factories to give delivery.

The new Central Aeronautic Research Institute which has just held its first meeting, has planned the establishment of a research station near Tokyo. The construction of a wind tunnel approximately 50ft. by 6oft. with motors totalling 40,000 h.p. will be started this year and is expected to take seven years to build.

U.S. Aeronautical Exports

THE astounding growth of aeronautical products exported from U.S.A. is shown in the following figures released by the U.S. Bureau of Commerce for the successive years: 1933, nine million dollars; 1934, 17; 1935, 14; 1936, 23; 1937, 39; 1938, 68; and 1939, 117 million dollars. Since 1911, 366 million dollars worth have been exported and this amounts to nearly one-third of the total national production. The proportion of total production now being exported has increased during the last two years. During 1939 France bought 42 and the United Kingdom 34 million dollars worth. The Netherlands Indies came third on the list with six million.

THE POTEZ 63

France's Number One Reconnaissance Machine : "Multi-purpose" Characteristics

The latest reconnaissance version of Potez 63 (type 63-11) as used by the French Air Force. It is powered with two Gnôme-Rhône 14-M. small-diameter radials giving 680 h.p. each at 13,200ft.

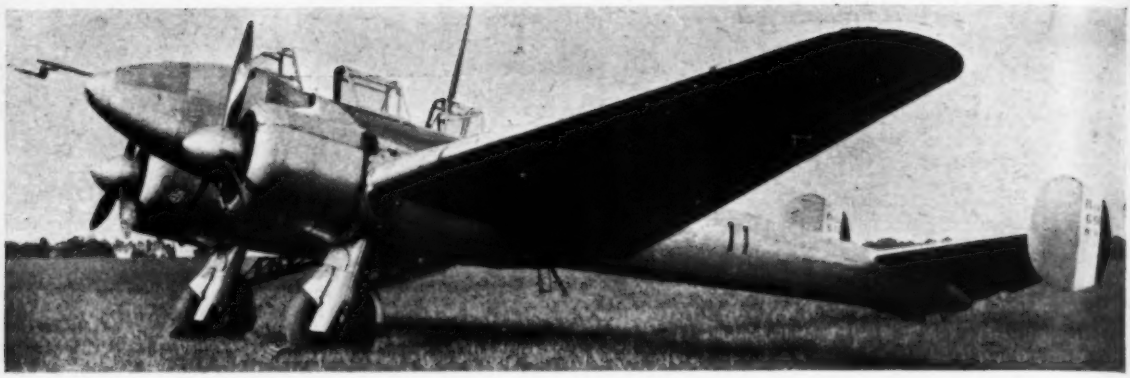
FOR reconnaissance flights over Germany, *L'Armée de l'Air* employs principally a specially built version of the Potez 63 twin-engined monoplane, though the Bloch 131, Martin 167, Bloch 174 and Lioré 45 are also available.

Already the type (which may be regarded as France's Blenheim) has been in action against German fighters and has acquitted itself with honours. Export versions have been delivered to Switzerland, Greece and Rumania.

In its original form (as exhibited at the Paris Show in 1936) the Potez 63 demonstrated the potentialities of the "multi-purpose" aircraft, being adaptable for fighting, bombing (including dive-bombing), reconnaissance, observation and ground attack. Actually, the machine was built for the French Air Ministry's three-seater fighter competition, for which the Breguet 690, Hanriot 220, Loire-Nieuport 20 and Romano 110 were also constructed. Eventually it was adopted for C.3 and B.2 duties (three-seater fighter and two-seater bomber), though the majority of machines now in use are equipped for reconnaissance.

Although differing considerably in layout and equipment, the various versions are structurally similar, and the following notes will apply in every case :—

The low cantilever wing has a rectangular centre-section which is built integral with the fuselage. There is a very heavy taper and sharp dihedral on the outer panels, which



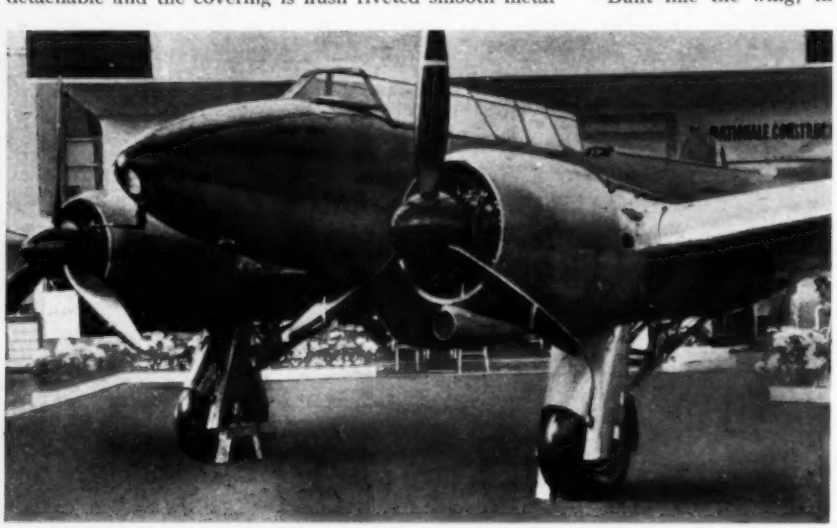
The three-seater fighter version of the Potez 63. The machine illustrated was one of the first off the production line and is powered with two Hispano-Suiza 14-Ab engines. The armament is two 20 mm. Hispano shell-guns and one machine gun.

are of two-spar type. Top and bottom spar flanges are made up of two tapered obtuse angled dural sections bolted together end to end with the aid of plates at a point about two-thirds of the span. Leading edges and wing tips are detachable and the covering is flush riveted smooth metal skin. It is possible to detach the lower wing surfaces.

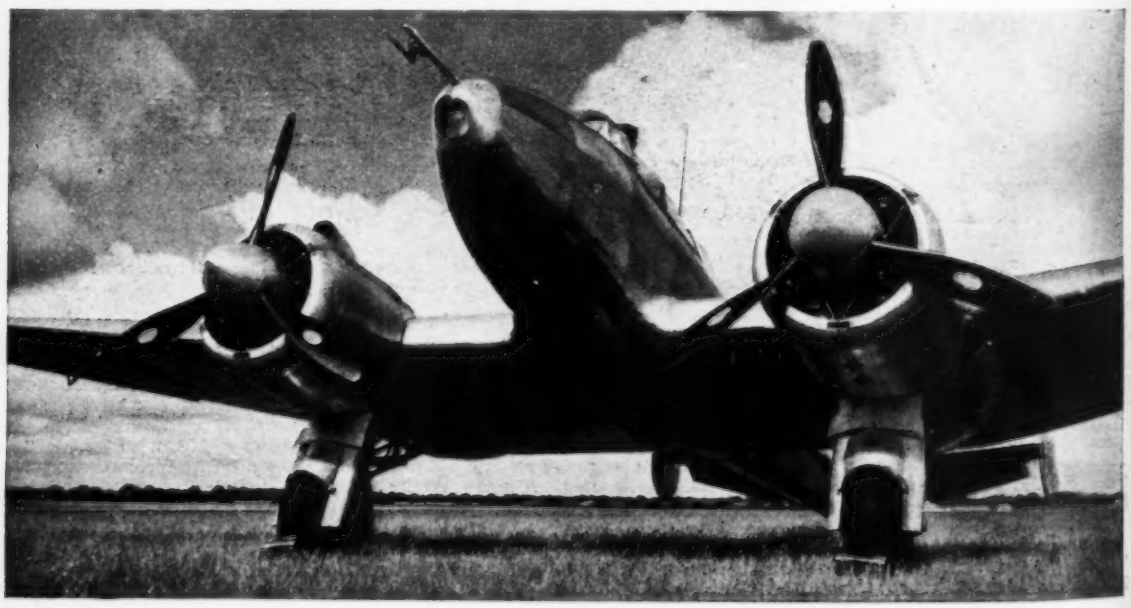
There are split trailing-edge flaps over the centre-section and part of the outer wing panels and, outboard of these, ailerons of high-aspect ratio.

Built like the wing, in three sections, the fuselage is long and slim. The centre-section houses the crew and embodies four obtuse-angled dural longerons to which are attached the stressed-skin panels. Monocoque construction is used for the nose and rear section; these are manufactured in halves.

Characterised by a pronounced dihedral angle (to give the necessary ground clearance for the twin fins



On the left is an earlier reconnaissance version than that shown on the previous page. It will be noted that there is an observation "box" beneath the fuselage. The fairings for the twin 20 mm. Hispano shell-guns are visible below the fuselage in the view below of a Potez 63 fighter. The machine illustrated has Hispano-Suiza engines.



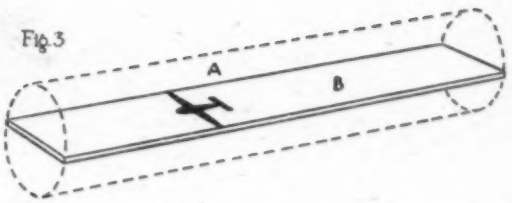
and parasitics will not be materially greater for the combination than for the individual components in sum, and so the *total* drag of the hypothetical combination will be less. Here it is only necessary to point out, (a) that the aspect ratio of the combination is greater than for the individual component machines†, and (b) that (as will subsequently be made clear) the speed of flight, for least resistance, will be lower for the combination, and so for a given value of V the conditions are not fully comparable.

The Best Compromise

The writer regards the " V " formation as the nearest approach and the best we can do towards a realisation of the tip-to-tip formation represented in Fig. 2a, the latter being obviously and candidly hypothetical. Thus in Fig. 2b the five machines shown flying in *echelon*, a " V " formation, tread the same band of air as would be trod by the same number of machines tip-to-tip as in Fig. 2a. It is clear that a part, not the whole, of the reduction in drag may be realised by this means.

In an appendix to a paper in November, 1936,* the writer presented his theory of sustentation in an unfamiliar form. This is illustrated in Fig. 3, in which a board B represents the track of the aerofoil of a machine represented in silhouette at A, the board B being supposed to extend indefinitely in both directions. If we consider the board as rigid, and as being subject to an impulsive force at right angles to its surface, it will give rise to a system of flow whose streamlines are given in Fig. 4, which represents a section at right angles to the direction of flight. The writer has shown that this system of flow is dynamically equivalent to a mass of air to which a uniform downward velocity is given, the mass in question being defined as that contained in an imaginary cylinder of circular section, whose axis coincides with the line of flight and whose diameter is equal to the span, i.e. in Fig. 3 the width of the board. This is as suggested by the dotted lines in the figure. The work done in setting up this system of flow is that which gives rise to the induced drag, and the equivalent as given provides the data by which it may be calculated. In the hypothetical mechanism by which the impulse is applied it is supposed that the *implement* (the board) is immediately dissolved; this is a convention familiar to all who have studied classic hydrodynamic theory from any of the standard works, such as Basset or Lamb. In accordance with the writer's theory, the aeroplane in its passage is deemed to " spread " the impulse, the resultant system of flow being identical with that produced by the hypothetical instantaneous action of the force applied to the board.*

Fig. 3



The quantitative interpretation of this may be expressed in the following manner. Consider a " length " of the imaginary board = L corresponding to a certain time of flight, say one second. Then the impulse on this length will correspond to the weight W acting for one second. But an " impulse " in strict theory has no sensible duration in time; its measure is momentum. In practice we may consider it as a finite force applied for a brief period, provided that the momentum is correct.

As before, let V = velocity of flight, and W be the load sustained, acting on a mass m for a time t to

† Impracticably so; otherwise the advantage might be a reality.

* See the Journal of the Royal Aeronautical Society, Feb. 1937, p. 111.

* Compare Proc. Inst. A.E. 1915, p. 200.

"Flight" photograph.

An early Whitley photographed from an Avro Commodore. There was a distinct lifting of the wing tip when it approached close to that of the Whitley.

"Flight" photograph.

A formation of which Dr. Lanchester would not approve. The machines are flying partly in bad "air." They are Gloster Gauntlets.

which it imparts a downward velocity v. Then, for a given distance $L = Vt$, $m = \frac{\pi}{4} \times S^2\rho\ Vt$ or, for time $t = 1$ second, $(m/s) = \frac{\pi}{4} \times S^2V\ \rho$ as in equation (1) above, and $W = v(m/s)$, which is the same as equation (2). And (3) and (4) follow.

From this it is manifest that the "new conception" illustrated by Fig. 3 is really the familiar vortex theory in disguise, resulting as it does in the same expression. It is nevertheless of value as representing in pictorial form a principle of fundamental importance.

Now for the application. In Fig. 2a the five aeroplanes, shown flying wing-tip to wing-tip, span a belt 5S in width; and likewise when flying in *echelon* in "V" formation, Fig. 2b, the same width of belt is spanned. This belt represents the width of the board in Fig. 3. In the first case, Fig. 2a, it has been demonstrated that, for a given speed of flight, the aerodynamic resistance or induced drag is the same for the five machines as for a single machine, and that this applies to any number greater or less. When flying in *echelon*, however, Fig. 2b, it is evident that this benefit cannot be fully realised, for we have only to specify the spacing (in the direction of flight) sufficiently great for the benefit to be lost entirely; each machine would then be flying solo. Thus all that can be affirmed is that the saving in the induced drag of a flight in "V" formation in practice, however substantial, can never be as great as that given as resulting from the tip-to-tip hypothesis, which must be regarded as a limit.

Admitting the above, it is nevertheless important to continue the quantitative investigation, because, whatever the practical limit may be, it is fair to assume that it will be in some degree related to the theoretical limiting value, and to have a basis of comparison between formations of different numerical strength is a matter of importance. Fig. 5 is a diagram—a plotting—in which graphs are given both for the *direct resistance per machine* x which is taken to be the same whether flying in formation or not; and for the *induced drag per machine*, which, being the same collectively when in tip-to-tip formation, varies *per machine* inversely as the number; these graphs are numbered according to the number of machines constituting the formation. The odd numbers only are given, the graphs for the even numbers are shown dotted.

The velocity for minimum total drag for a single machine is given as V_1 and, the lowest number of machines forming a symmetrical formation being three, it will be seen how great a reduction in induced drag results on the tip-to-tip hypothesis. The benefit of increasing the number of machines to five is small in comparison, and the further benefit given by an increase to seven is less again: this is at constant velocity V_1. But, the velocity of least total drag being that at which the direct resistance and induced drag are equal,* the correct velocity (flight speed) is lower for a flight in formation than for the single machines of which it is composed, and in Fig. 5 this is shown in relation to V_1 by the values V_3, V_5, and V_7.

In Fig. 6 graphs are given of the *total* flight resistance or drag on the same basis. It may be observed how much greater is the saving effected if the velocity of flight be reduced to correspond with the condition of least drag. The relative values are given by corresponding numbers on the left-hand side of the figure

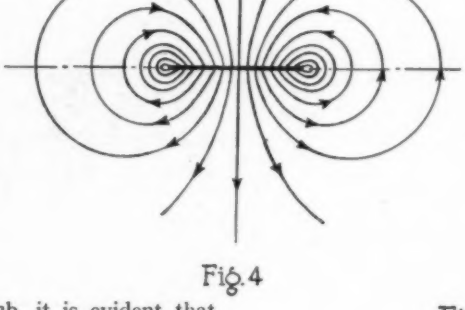
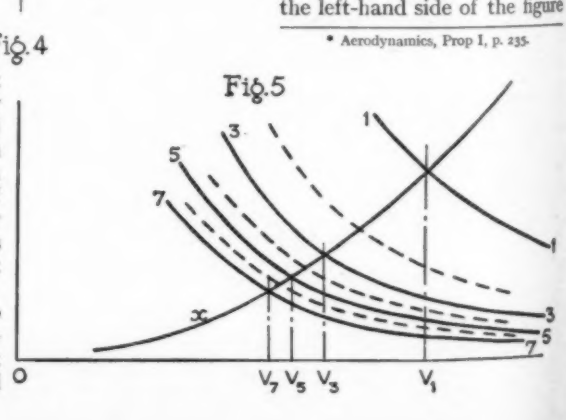


Fig. 4

Fig. 5



* Aerodynamics, Prop I, p. 235.

distinguished by an accent, thus 1′, 3′, 5′ and 7′.

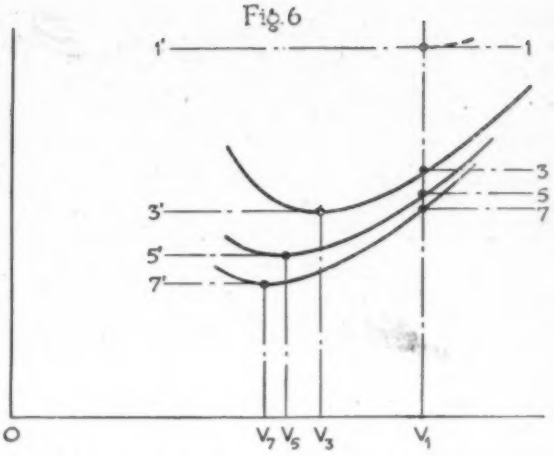
The graphic form of expression is all that is needed in view of the fact that all values relate to the hypothetical condition of a formation not capable of realisation. Whatever can be achieved by the " V " formation, even though it be only a fraction of that shown, the underlying principle is the same, and the difference is one of degree. The benefit of flying in formations of three will be less than given in the figures, but that due to flying in formation of five or seven will also be less, and in something like the same proportion. Likewise the best and most appropriate flight velocity may be judged in a qualitative sense from the relative values V_1, V_3, V_5, V_7 given.

The Leader's Task

There would appear to be no doubt that in the " V " formation the leader is operating under conditions scarcely easier than those which obtain when flying solo; this is confirmed by observations on birds. It has more than once been reported that, flying in " V " formation, the leader may be seen to fall back and be replaced by one of those second in position. Whatever the difference may be it must depend to some extent upon the distance (in the direction of flight) separating the leader from the next in position.

Whilst theory points to the desirability of reduced speed for a flight in " V " formation, it must not be forgotten that without any reduction of speed the formation results in a saving, and that consequently, for a given expenditure of fuel, aeroplanes in " V " formation could, if occasion were to arise, fly faster than the same machines proceeding independently.

Fig. 6



"Exit Civil Aviation"

IT has been found necessary to hold over to next week the concluding part of our correspondent's article "Exit Civil Aviation?" owing to an unavoidable lack of space. But in the meantime readers' attention is drawn to "A. Viator's" comments on civil aviation in his usual cheery style on page 283.

Small German Twin-engined Gotha

THE Gothaer Railway Car Factory at Gotha has produced what is probably the smallest "twin" in the world. It is a cabin plane with two 50 h.p. Zundapp engines, and is reported to have reached an altitude of 26,397ft. in a 90-minute flight. Cruising speed is given at 115 m.p.h. and maximum at 124 m.p.h.

"Levelator" Reduces Assembly Time

THE Grumman Aircraft Engineering Corporation, at Bethpage, N.Y., have installed one and ordered five more "lifts" to aid assembly work. Made by the Rotary Lift Co., of Memphis, Tenn., the device is known as a "rotary levelator" and is used for raising and lowering an aeroplane during the assembly processes so that workmen can do all their work while standing on the floor without any necessity to go up and down ladders and working platforms. The "levelator" is a platform 40ft. by 6ft. which can be easily raised or lowered relative to the factory floor by the two hydraulic pistons on which it is supported. Differential movement of the pistons allows the platform to be tilted with one end four feet above the other. It is stated that the Grumman company saves 800 man-hours of assembly labour on each aircraft by use of the device.

Lockheeds for South Africa

IT is announced that the Railways Administration in South Africa (under the Union Minister for Railways, Harbours and Airways) has signed a contract for sixteen of the latest Lockheed airliners, the twin-engined Lodestar. The price is said to be about £25,000 each, a total of £400,000, without airframe and engine spares which are to be ordered later. It is also reported that the purchase of two of the bigger four-engined Lockheed liners, the Excalibur, is under consideration.

It is apparent that the Union of South Africa is not going to let its civil aviation languish in wartime, even though the 18 Junkers Ju. 86 which made up most of the South African Airways fleet before the war, have been taken over for military use on "seaward defence." The replacement of these by the Lodestars is just one more example of how British markets are being presented to the enterprising American aircraft industry.

Flying at Malta

NOTICE to Airmen (Emergency Series) No. 86, paragraph 1, concerning flying at Malta, is amended as follows:—

In lines 14, 22, and 23, delete "Ta Kali and Hal Far" and substitute "Luqa." In line 32 delete "Ta Kali" and substitute "Luqa."

No. 1 GETS ANOTHER No. 1: Thirty years ago Lt. Col. Moore-Brabazon, M.C., M.P., obtained the first aviator's certificate issued by the Royal Aero Club. "Moore-Brab" has now been allocated a set of very appropriate car registration letters.

A section of Spitfires "beating up" their aerodrome for the benefit of pressmen. This practice is normally discouraged except after a victorious action.

FIGHTER STATION

With the Spitfires in Scotland

By H. F. KING

Illustrated by "Flight" photographs

AT Crecy we had long bows; on the Somme the tanks; and in this war we have the eight-gun fighters.

Our Spitfires and Hurricanes may not be of such a revolutionary character (though their success is attributable to certain unique qualities), but their designers have given our defences that "extra little something" which is lacking in the *Luftwaffe*: tractable fighters which can be used with impunity by day or night and which have a superiority in armament over any single-seater fighters yet in service.

These machines are as popular with their pilots and the public as they are dreaded by the Germans. In six months their names have become everywhere familiar, and their qualities and accomplishments are known to errand boys, kitchen maids, fishermen and bankers.

The Air Ministry is well satisfied, and we suspect that it was not without a certain pride that *Flight* was invited to visit a typical fighter squadron in Scotland. We say typical, though actually it belongs to a sector which can claim the biggest bag of enemy aircraft since the war began: nine Heinkels and Dorniers out of sixteen interceptions. Two pilots have been awarded the D.F.C. Units from the station tackled the raids on the Firth of Forth, and it was from the same aerodrome that a Spitfire squadron took off and brought down an He 111K off St. Abb's Head. Another of the Spitfire squadrons housed there shot down the first German bomber to fall on British soil; this was the Heinkel which made a crash landing on the Lammermuir hills near Dalkeith. Before the war the unit was a squadron of the Auxiliary Air Force, manned by young Glasgow men.

Such stations as this are administered by the Fighter Command, R.A.F. (Air Officer Commanding-in-Chief, Air Chief Marshal Sir Hugh Dowding) and are responsible for close defence at Home from air attack. Up to the moment, although forty German bomber or reconnaissance machines have been destroyed by the Fighter Command, not one of our fighters has been brought down.

The modern fighter pilot is the first to admit that air defence to-day is essentially a matter of team work. Particularly does he praise the patient, watchful enthusiasts of the Observer Corps who report his every movement. Here we may interpose the story of the *Ogle Pogle*.

Before this inelegant sobriquet was conferred on a particular Spitfire its pilot, patrolling at a great height over point A, had been directed, on information from the Corps, to investigate a machine over B. Arriving there he was redirected to A for the investigation (unbeknown at that time to himself or the Corps) of his own aircraft. By the time he had reached A he had again been signalled to B, where his presence had been duly reported. And so round he went in circles like the fabulous Ogle Pogle bird which, history tells us, flew in ever-decreasing circles, finally performing an astounding feat of contortion.

Students of Service jargon may wish to note that to be "ogle-pogled" is to become involved in one of these roundabout patrols.

Other machines were inscribed *Harpo*, *Groucho*, *Chico* (probably one of the flight leaders is a student of Marx), *Sheepdipper* (was this inspired by *The Lion Has Wings?*) *Bogus* and *Duck*.

As for the station itself we could not, even if permitted, give a very vivid picture as it is purposely made as featureless as possible. Despite the architectural drabness, the place is pervaded with an air of alertness.

The Officer Commanding, Group Captain Kearey, received us in the ante-room of the mess and led us out on a personally conducted tour. On the way to the Link

Scale models of German aircraft are used for instruction in zones of fire. Gun positions are represented by small illuminated bulbs.

Trainer rooms, in which the pilots spend three hours a month on blind-flying or Lorenz beam practice, the C.O. drew our attention to the comprehensive system of Tannoy loud-speakers through which instructions and warnings can be broadcast to every part of the aerodrome buildings. On the wall of one of the Link rooms was a photograph of German Air Force pilots receiving instruction on what appeared to be almost identical equipment. In the parachute section (in charge of a corporal and run on a "station," rather than a "squadron," basis) we recalled also that the German parachutes are similar in design to our own.

Later, in a sombre Bellman hangar through which we passed (this is a lofty corrugated iron affair which is quickly erected and dismantled) we saw fitters removing a cylinder block from a Merlin engine. Six others—two to a blade—bore off the big De Havilland v.p. airscrew.

Relaxation

A walk between the hangars beyond brought us to the rest room used by the pilots commanded by Wing-Commander Farquhar, one of the station's D.F.C.s. Within, this was essentially homely and the mural decorations were not all aircraft-identification charts; obviously the pilots' appreciation of streamlining is not confined to their Spitfires.

The "stand-by" pilots receive action warnings over the loud-speakers. If not relaxing on one of the beds they may divert themselves with a game of chess. In daytime they are normally released for meals, but if this is impractical food is sent from the mess in thermos containers.

More impersonal, though to our mind of supreme interest, was the armoury, where a Warrant Officer spared himself no trouble to explain his deadly charges.

That its thin insect-like wings can house so unobtrusively such a destructive concentration as eight 0.303in. Browning machine guns with their long ammunition belts, feeding, heating and firing arrangements, is but one of the remarkable points of the Spitfire.

On both the Spitfire and the Hurricane the eight guns, which are fired by compressed air, are housed entirely within the wings although the grouping is different in each machine. On the Spitfire there is one gun just outboard of the airscrew arc; then there is a considerable space before the leading edge is pierced by a pair of closely spaced ports; and beyond these is another wide space, the fourth gun being well out toward the wing tip. The belt boxes (or "ammunition tanks" as they are sometimes called) are loaded into the wing from beneath, being held in place by spring clips, and the first round of each belt is pulled through with a piece of webbing, being loaded from the top surface of the wing, which has detachable panels. The webbing idea was first thought out in the squadron concerned, and is now standard throughout the Service. It is said to effect a considerable saving of time in rearming.

On the left is Group Captain C. R. Keary, Officer Commanding a fighter station in Scotland. In black overalls is Wing Commander A. D. Farquhar, D.F.C., who has three Heinkels to his credit.

Relaxation in the pilots' rest room. As will be seen in the lower view *Flight* identification drawings are in evidence though these—be it said—are not the decorative *motif!*

The rate of fire is approximately 1,200 rounds a minute per gun.

The Warrant Officer told us that he is continually impressing upon his men the importance of their work. We watched them coating the Brownings with anti-freeze oil, cleaning the barrels and making up ammunition belts. Obviously, they are conscious of their responsibility.

The belts are composed of cartridges held together by metal links. Each round is a finger-tight fit into its link, but the final alignment to ensure correct feeding is done on an ingenious machine. Evenness of feed is absolutely essential, for the guns, being placed in the wings, are not accessible from the cockpit and it is not considered worth while to

The pilots in the group above are appraising the take-off of a flight of Spitfires on a practice interception.

All for one: A Spitfire's eight 0.303 in. Browning guns, each capable of firing 1,200 rounds a minute, after overhaul in the armoury (below).

Below a Spitfire pilot demonstrates the use of the reflector sight with which our fighters are fitted.

fit them with remotely controlled cocking handles. The actual make-up of the belts (i.e., proportion of armour-piercing and tracer to "ordinary" ammunition) is secret, though it can, of course, be varied to suit the particular requirements of Fighter Command. Empty cases and links are ejected through apertures in the bottom of the wing. Contrary to what might have been thought the empties do not damage the fabric-covered ailerons.

Heating for the guns is provided by a hot-air duct from the engine. The gun compartments are made more or less air-tight until the first burst is fired by patches of fabric which cover each port. These also improve the performance of the machine and decrease the chances of corrosion. After an action they are replaced, if time permits, before the next engagement. Fitters, riggers and sometimes even pilots assist in the rearming which, together with refuelling, can be completed in less than ten minutes.

We were also shown the standard reflector gun sight in which the illuminated image of a ring sight is projected on to an oval mirror in front of the pilot's eyes and behind the armoured windscreen. If the pilot knows the span of his adversary he can adjust his sight "to fit" and knows immediately he is within range. Ordinary ring and bead sights are provided in case the electric supply should fail.

As is now generally known the lines of fire of the eight guns converge at a set point in front of the machine and harmonise with the sight.

Fighters are now going into action carrying their ciné-camera guns which use 16 mm. film and prove or refute a pilot's combat report. The camera gun works only while the machine guns are firing and secures an amazingly detailed record of a combat. Sqn. Ldr. Farquhar's last engagement with an He IIIK was reproduced faithfully by his ciné-camera; it was possible to see oil spurting from

The Spitfire usually flown by Wing Commander Farquhar is marked with a British lion trampling underfoot the Nazi swastika. It will be seen that two small Nazi flags are "cancelled"; actually the Wing Commander has accounted for three Heinkels to date.

A thirty-hour inspection is a more pleasant task if performed in sunshine. Here are fitters and riggers engaged on this routine task in the doorway of a Bellman hangar.

an engine nacelle after the machine had been hit. Having some film remaining after the Heinkel had hit the water the Squadron Leader flew low over the wreck and secured some further views.

This unique strip of celluloid we were not shown, though for our benefit four practice films were screened. A circle is first projected to represent the gun sight reflection ring and a cross marks the centre. The first film recorded a mock attack on a Spitfire from astern ; the second a similar attack on a Blenheim ; and the third and fourth attacks by a section of Spitfires on another section from the beam (here the aiming off was well demonstrated) and from astern. The accuracy of aim was remarkable despite the obvious effect of the quarry's slipstream in the stern attacks. Training with the camera gun alone does not, of course, reproduce faithfully actual conditions, for the recoil of the eight guns naturally causes a decrease in speed and a dropping of the nose.

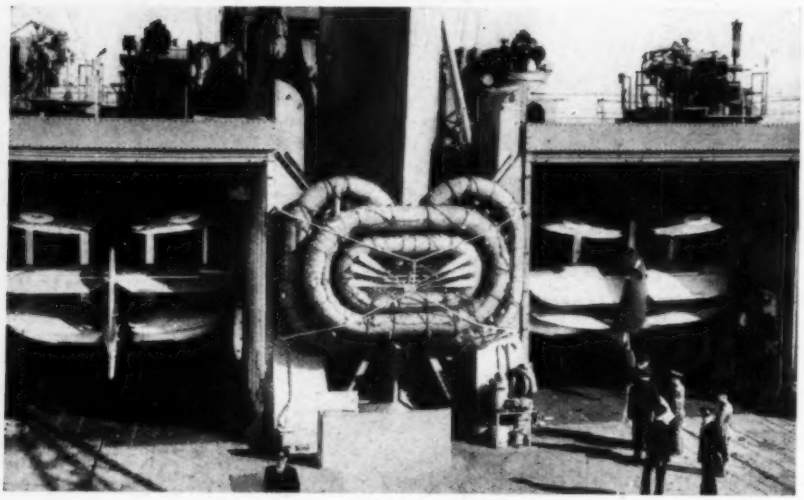
At the butts we saw and heard (standing just in line with the leading edge) three Brownings fired simultaneously. The shattering crackle was accompanied by cascades of cases and links which danced about the tarmac, and the smell of cordite, as smoke poured from the apertures in the wings.

The C.O. had arranged for a fighter Blenheim to come

(*Concluded on page* 295.)

Hundred-octane fuel surges along the triple arms of a Zwicky unit into the tanks of Spitfires.

SERVICE AVIATION



SHIPBOARD STOWAGE : How two Supermarine Walrus amphibian flying boats (Bristol Pegasus VI) are housed aboard some of our cruisers.

Duchess of Gloucester and W.A.A.F.s.

AIR Commandant H.R.H. The Duchess of Gloucester paid her first visit to the Air Ministry on March 19. She was wearing W.A.A.F. uniform. The Duchess was received by the Director of the W.A.A.F., Air Commandant J. Trefusis Forbes, who presented the officers of her Directorate.

Balloon Barrage Men Wanted

A LARGE number of men are needed by the Royal Air Force for the balloon barrage, which since the war has been greatly extended. Seventy-five per cent. of the men, who must be between the ages of 35 and 45, are wanted as balloon operators. The others, between 18 and 42, must have heavy goods vehicles drivers' licences, as they are needed as drivers of balloon barrage lorries. For both trades the pay will be 2s. a day on enlistment, with the usual allowances. When qualified as balloon operators, pay will increase to 3s. 6d. a day, with further increases on promotion.

London Gazette

Royal Air Force

General Duties Branch.

The following ex-Flight Cadets are granted permanent commissions as Pilot Officers on probation (March 7):—C. E. Beloe, B. R. Champion, G. E. Chandler, M. W. Coombes, M. H. Dalzell-McKean, J. O. Dyer, A. F. Fegen, M. J. Herrick, I. M. Hossack, P. I. Howard Williams, J. G. Lecky, T. de T. MacDonald, E. S. Marrs, H. Mundy, M. Negus, R. C. L. Parkhouse, J. A. Plumb, J. H. Rothwell, J. N. Rowland, A. A. J. Sanders, R. A. Shuttleworth, J. A. Sowrey.

The following are granted commissions for the duration of hostilities as Pilot Officers on probation (Jan. 17):—P. Burnhill, W. G. Edwards, R. Gatford, A. J. D. Hitchman, C. T. Kimber, J. Oliver, F. J. Rimer, A. A. Scott, F. J. Swain, F. J., Watson, R. E. Wesson, T. J. Cranidge, L. H. Ewels, H. E. Grellis, F. Hartnell, A. L. Holland, C. A. Kidd, F. M. Morison, H. Parkinson, W. Sanders, W. J. Hadnett.

Leading Aircraftmen.—P. F. Dunham, R. C. Fishlock, C. W. Grant, M. Kenny, G. Moir, F. M. N. Searle, W. J. Read.

Aircraftman 2nd Class:—R. C. Hall.

The following Acting Pilot Officers on probation are graded as Pilot Officers on probation on the dates stated:—(Nov. 6, 1939) M. A. Butler; (Feb. 18) C. Orme, C. B. Rigg, N. E. Canton, L. A. S. Grumbley, M. H. Hankins, J. H. D. Mercer, D. E. Stewart; (Feb. 24) C. F. Ambrose, A. G. H. Lindsell, J. C. M. Mountford, P. N. B. Parsons, R. G. Winnicott; (Feb. 28) G. C. T. Carthew, R. D. Rutter, G. E. Goodman, P. L. Jarvis, D. H. Wissler; (March 2) F. H. James, D. F. Lamb, C. I. Malcolm, B. R. Mercer, F. G. Millar, D. R. Mitchell, A. H. Poulsen; (March 2) J. Rea, V. C. Simmonds, D. N. Woodger, E. W. Wootten, P. W. M. Carlyon, P. M. Dobree Bell, S. G. Tartar.

The following Flying Officers are promoted to the rank of Flight Lieutenant. (March 16):—P. A. Tipping, D. J. McGlinn, B. P. King.

The following Pilot Officers are promoted to the rank of Flying Officer on the dates stated:—(Feb. 16) E. G. Rands; (Feb. 18) A. J. H. Finch; (Feb. 23) N. A. Edwards, J. C. Simpson; (Feb. 24) N. McClelland; (March 16) M. W. Rumsey, D.F.C., J. E. McFall, D.F.C., F. S. Holman, G. O. Ross, C. W. S. Thomas, M. E. Abbott, H. C. Down, F. J. Austin.

Flying Officer C. D. S. Smith relinquishes the acting rank of Flight Lieutenant (Jan. 1).

Squadron Leader W. G. Woolliams is placed on the retired list on account of ill-health (March 9).

The short service commission of Acting Pilot Officer on probation T. M. Calderwood is terminated on cessation of duty (Feb. 15). (Substituted for notification in the *Gazette* of Feb. 13.)

The short service commission of Acting Pilot Officer on probation J. F. Hart is terminated on cessation of duty (March 13).

Royal Air Force and Official Announcements

Pilot Officer S. J. Scammell is cashiered by sentence of General Court-Martial (March 7).

Equipment Branch.

The following Pilot Officers on probation are confirmed in their appointments on the dates stated.—(Jan. 2) W. G. Sansom; (Jan. 23) F. W. Powell, E. V. Davies, D. Moulden, E. Towers, D. E. Henderson, J. P. W. Purves.

The undermentioned Pilot Officers on probation are confirmed in their appointments and promoted to the rank of Flying Officer on the dates stated.—(Jan. 2) D. M. Bidwell, M. B. Cooper, J. D. E. Davies; (Jan. 23) P. R. M. Groom; (Jan. 31) I. P. D. Stocker.

Medical Branch.

The following Flying Officers are promoted to the rank of Flight Lieutenant on the dates stated:—(Jan. 9) (seniority April 9, 1939) G. L. Burgess, M.R.C.S., L.R.C.P.; (Feb. 28) (seniority Feb. 28, 1939) J. P. F. Whelan, M.B., B.S.

Royal Air Force Reserve

RESERVE OF AIR FORCE OFFICERS.

General Duties Branch.

Capt. M. K. St. J. Carpendale (R.A.R.O.) is granted a commission in class CC as Flight Lieutenant (Feb. 10).

Squadron Leader A. J. Currie (R.A.F., ret.) is granted a commission in class CC as Flight Lieutenant (Sept. 2, 1939). (Substituted for notification in the *Gazette* of Feb. 2.)

Major W. J. C. Brown is granted a commission in class CC as Flying Officer for the period Sept. 14, 1939, to Jan. 31, 1940, inclusive.

The following Flight Lieutenants are granted the rank of Squadron Leader on the dates stated:—(April 12, 1939) J. Kemper, M.B.E.; (Jan. 9) J. F. R. Massy-Westropp, M.B.E.

The following Flying Officers are transferred to the Administrative and Special Duties Branch on the dates stated:—(Nov. 28, 1939) C. Kenney; (March 6) M. G. Parker.

Flying Officer W. H. Bowen relinquishes his commission in class CC on appointment to a commission in the Royal Air Force Volunteer Reserve (Sept. 1, 1939).

The following relinquish their commissions on cessation of duty on the dates stated:—Flight Lieutenants: (Dec. 11, 1939) W. M. Anderson; (Feb. 8) H. A. Sawyer, M.C.; (Feb. 11) N. Noble, M.C. Flying Officer: (Feb. 19) L. O. Welch.

The notification in the *Gazette* of March 12 concerning Flight Lieutenant F. G. Mason is cancelled.

Royal Air Force Volunteer Reserve

General Duties Branch.

The following are granted commissions for the duration of hostilities as Pilot Officers on probation on the dates stated:—(Feb. 1) D. E. Milebam, D. E. C. Myland, M. J. D. O'Leary, N. S. Parrott, D. Passmore, J. C. Peterson, P. E. Penfold; (Jan. 17) C. S. Hawley.

The following are granted commissions for the duration of hostilities as Acting Pilot Officers on probation on the dates stated:—(Feb. 4) R. D. Hanbury; (March 2) S. V. Alderton, V. V. L. Clarke, J. P. Lees, A. J. Putt, K. W. Robinson, R. M. Taylor, C. S. Watkinson, N. G. Wilson.

Pilot Officer on probation C. S. Goodfellow is transferred to the Administrative and Special Duties Branch (March 2).

The following relinquish their honorary commissions on cessation of duty on the dates stated:—(Dec. 3, 1939) Wing Cdr. H. G. Gauntlett; (Dec. 26, 1939) Flt. Lt. A. C. Hootton.

Administrative and Special Duties Branch.

The following are granted commissions as Flying Officers with effect from Sept. 1, 1939, and with seniority of the dates stated:—(May 22, 1939) W. H. Bowen; (Aug. 14, 1939) W. F. Norvell.

The following are granted commissions for the duration of hostilities as Pilot Officers on probation on the dates stated:—(Oct. 18, 1939) S. G. Frogley, D.S.O., D.F.C.; (Nov. 23, 1939) A. R. Smithwick, D.S.O.; (Dec. 5, 1939) F. J. Maggs; (Dec. 26, 1939) W. G. Roberts; (Feb. 10) J. K. Rickard; (Feb. 12) J. A. M. Faraday; (Feb. 14) M. W. Turner; (Feb. 15) L. T. Smith; (Feb. 16) H. C. Cooke, A. A. Crooke; (Feb. 17) A. J. Ilow; (Feb. 18) C. F. Trench, D.S.O.; (Feb. 19) R. G. Cookson, J. H. F. Heche; (Feb. 20) J. F. Warren; (Feb. 21) O. Plant, F. C. Whitten; (Feb. 22) B. J. Guest, H. D. Gunton, G. C. Lugg, W. L. Wood; (Feb. 23) K. Fraser, A. J. Jewell, C. B. Marshall; (Feb. 24) G. W. Holey, G. H. Ramsay; (Feb. 25) H. O. Evans; (Feb. 26) D. S. Allom, T. A. H. Boddington, S. Beeby, D. W. Bridge, C. H. Coates C. Collings, W. F. Conway, O. W. H. Cooke, S. A. Cox, C. D. De Bosdari, W. C. Garrett-Petts, H. W. W. Hatch, P. B. H. Home, A. Lee, B. A. Leigh, J. D. K. Lloyd, A. R. Nock, D.F.C., J. R. Robinson, H. H. Rose, C. A. Taylor, H. Tempest, F. C. Walker, D.C.M., G. F. L. Woodhouse; (Feb. 27) B. T. Anderson, O. L. Beater, R. E. Casalis De Pury, T. V. Craig, F. J. Cridlan, J. Duncan, E. E. Hodgson, D. V. Kidman, E. R. Legh-Jones, P. W. Loveday, H. H. B. Newbury, S. H. Price, E. W. H Smith, C. Welton; (Feb. 28) O. H. Brown, F. Le H. Ginger, R. H. N. Saunders, T. G. Skinner, E. C. S. Weale; (Feb. 29) H. F. Bath, A. E. Dennis, M.M., G. E. Evington, L. H. Graham, J. D. Worthington; (March 1) A. D. Pate, G. W. Stallard; (March 2) E. J. L. Ross.

D. R. Pelmore is granted an honorary commission in the rank of Flying Officer (March 5).

The following Pilot Officers on probation are confirmed in their appointments and promoted to the rank of Flying Officer on the dates stated:—(Aug. 27, 1939) F. D. Luzard; (Sept. 1, 1939) T. W. S. Snider, T. W. Sheppard; (Sept. 8, 1939) R. A. Bradford, D. R. Gillie, G. S. Myers, J. R. Pearson; (Sept. 9, 1939) E. D. Skepper, V. A. Stoneham; (Sept. 11, 1939) E. J. Tippett; (Sept. 13, 1939) S. S. Kirsten; (Sept. 24, 1939) O. L. Day; (Oct. 16, 1939) A. J. Macnab, M.C.; (Nov. 4, 1939) H. B. Jenkins.

Pilot Officer on probation H. G. Bradshaw takes rank and precedence as if his appointment as Pilot Officer bore date Nov. 12, 1939. Reduction to take effect from Feb. 24.

F/O. J. G. Critchley resigns his commission (Feb. 19).

The commission of Pilot Officer on probation L. W. B. Winship is terminated on cessation of duty (March 13)

Equipment Branch.

G. A. Chittock is granted a commission for the duration of hostilities as Pilot Officer on probation (Oct. 12, 1939). (Substituted for notification in *Gazette* of Nov. 28, 1939.)

The following are granted commissions for the duration of hostilities as Pilot Officers on probation on the dates stated:—(Sept. 29, 1939) T. C. Noble; (Nov. 13, 1939) A. F. J. Copson, G. P. Debono; (Nov. 20, 1939) V. H. Quinn. (Substituted for notification in *Gazette* of Dec. 5, 1939.)

The following Pilot Officers are promoted to the rank of Flying Officers on the dates stated:—(Nov. 17, 1939) J. R. Turnbull; (Dec. 28, 1939) E. D. B. Payne; (Jan. 5) A. E. B. Rich; (Jan. 26) M. J. P. F. H. D'A. de Froberville, E. J. Vince; (Feb. 2) A. H. Seymour; (Feb. 16) H. C. Kendall; (Feb. 23) G. S. Sawtell; (Feb. 29) H. F. R. Temple; (March 6) F. H. Whiteley; (March 13) J. F. Hinks, T. ap Simon.

Accountant Branch.

A. Siddall is granted a commission for the duration of hostilities as Pilot Officer on probation (Sept. 3, 1939).

Medical Branch.

The following Flying Officers are promoted to the rank of Flight Lieutenant on the dates stated:—(Feb. 21) M. P. Morel, M.B., Ch.B., M.R.C.S., L.R.C.P., F.R.C.S.; (Feb. 29) C. L. Clinton Thomas, M.R.C.S., L.R.C.P.

Chaplains' Branch.

The following are granted commissions for the duration of hostilities with the relative rank of Squadron Leader on the dates stated:—(March 5) The Rev. J. C. Salisbury, the Rev. B. H. C. Wilson, B.A.; (March 7) the Rev. D. Johnston.

Errata.

In the *Gazette* of Feb. 23, 1940. For 747816 D. S. Waller read 747816 D. S. Wallen.

In the *Gazette* of Feb. 27, 1940. For L. E. Pierrard read L. E. Pierard.

Auxiliary Air Force

General Duties Branch.

No. 608 (NORTH RIDING) SQUADRON.—F/O. H. J. Williams is transferred to the Administrative and Special Duties Branch (Dec. 9, 1939).

No. 920 (WEST LANCASHIRE) SQUADRON.—F/O. W. Joanes, M.B.E., relinquishes his commission on account of ill-health (March 11).

No. 949 SQUADRON.—Lt.-Col. Lord H. Scott, C.M.G., D.S.O., D.L., is granted an honorary commission as Air Commodore (March 19).

The notification in the *Gazette* of Feb. 2, 1940, concerning Flt. Lt. G. A. W. Garland is cancelled.

Administrative and Special Duties Branch.

No. 603 (CITY OF EDINBURGH) SQUADRON.—A. Wallace is granted a commission as Pilot Officer with effect from Feb. 20, 1940, and with seniority of Nov. 29, 1939. (Substituted for notification in *Gazette* of Feb. 23.)

Women's Auxiliary Air Force

The following are appointed Assistant Section Officers (March 9):—Cpl. Miss U. M. Bradley, Aircraftwoman 1st Class Miss B. A. Brock, Aircraftwoman 2nd Class Miss H. A. Craig, Cpl. Miss D. Y. Delius, Aircraftwoman 2nd Class Miss A. V. Hamilton-Grace, Aircraftwoman 2nd Class Mrs. C. M. Moor, Cpl. Miss M. E. Prestwich, Aircraftwoman 1st Class Mrs. M. H. D. Russell Roberts, Cpl. Miss R. P. Watson.

Assistant Section Officer Miss N. M. Lloyd relinquishes her appointment, on account of ill-health (March 5).

Flight Officer Mrs. J. Graham relinquishes her appointment (March 15).

Flight Officer Mrs. J. E. Holcroft relinquishes her appointment on ceasing to be employed (March 15).

Erratum.

In the *Gazette* of March 12, 1940. For Cpl. Mrs. M. Ives read Cpl. Mrs. H. M. Ives.

Professor Hill's Appointment

PROFESSOR A. V. HILL, M.P., O.B.E., F.R.S., has been appointed as Assistant Air Attaché, Washington, for special scientific liaison duties. The appointment is a temporary one and has been accepted without remuneration.

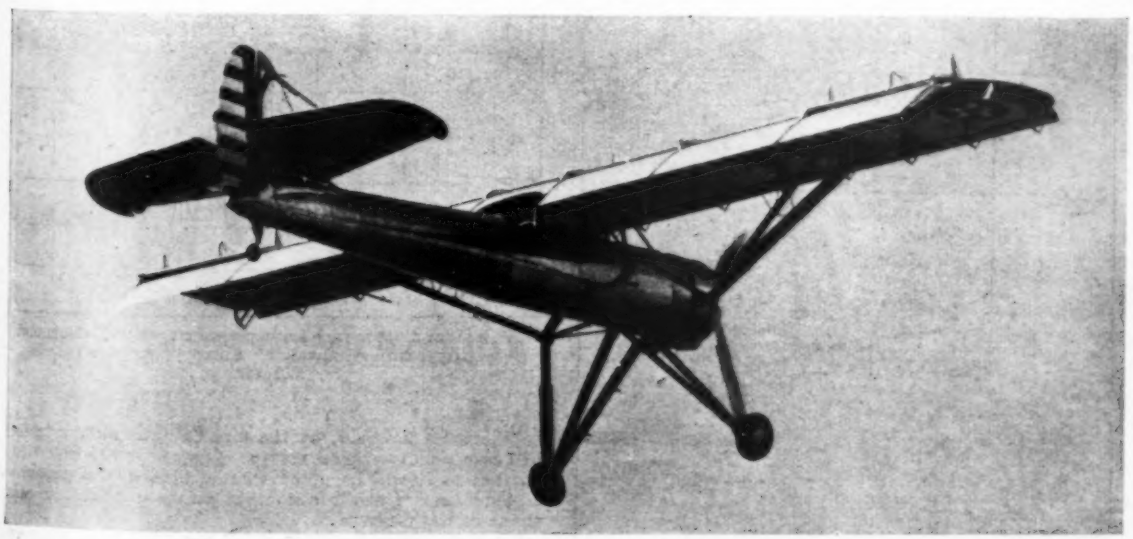
FIGHTER STATION (CONCLUDED)

over and play the rôle of an enemy bomber. The Bristol flew across the aerodrome full out, which led one to suggest that, like the Spitfires' Merlins, the Mercurys were burning 100-octane fuel. But the Spitfires overhauled it and one by one simulated a stern attack "opening fire" at what must have been 400 yd. range. As one pilot broke off his attack and wheeled away another Spitfire closed in to cover him.

In the afternoon a flight of Spitfires staged some plain and fancy "beat-ups" of the aerodrome in formation (excellent vic and echelon) and singly after a peel-off. This pastime is normally frowned upon, though a certain amount of *joie de vivre* is countenanced if the machines concerned are returning from a victorious interception or if they are demonstrating for pressmen. Here, again, the 100-octane fuel (which enables the Merlin to receive no less than 12 lb. boost in emergency) must have been an asset.

After this manifestation of power we found it restful to inspect small models of enemy aircraft which, although not entirely up to date, suffice to demonstrate, by means of luminous bulbs, the gun positions on the various machines. Thus the blind spots can be pointed out.

CO-OPERATIVE



The new Ryan YO-51 light army co-operation machine built to the Fieseler Storch formula. Fully slotted and flapped, it can be operated from extremely small spaces and is enabled to fly very slowly for artillery spotting.

THE AIRCRAFT ENGINEER

No. 170. (Volume XIX No. 3) 15th Year March 28 1940

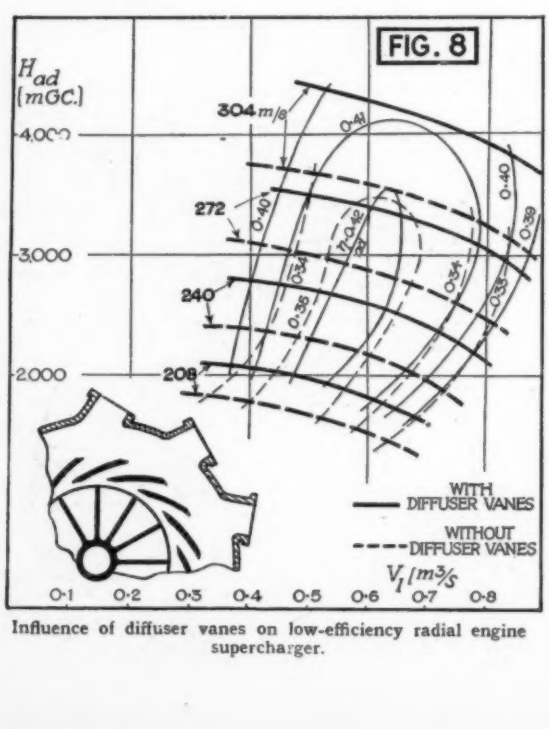
GERMAN SUPERCHARGER TESTS

By Dr. ING. P. F. MARTINUZZI

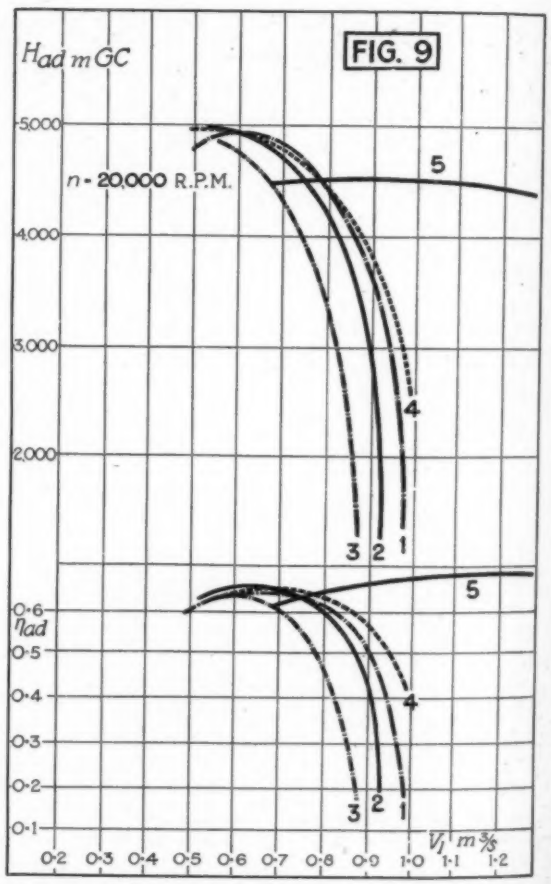
(*Continued from page 8, February 29, 1940*)

MANY tests have also been made on the effect of the arrangement of the diffuser vanes. Fig. 8 shows the improvement brought about by fitting diffuser vanes to a vaneless, low-efficiency blower for a radial engine. This type of blower is still used in great numbers. Though blowers seem to fit radial much better than V-type engines, in reality the small available outer diameter and the separate inlet pipes to the single cylinders, which prevent the use of a spiral volute, cause radial engine blowers to be less efficient than other types. In the case of Fig. 8, the absolute gain of 7 per cent. represents a relative gain of 20 per cent. over the vaneless type. The reduction in engine inlet temperature can make an enormous difference, particularly with air cooling.

While the use of diffuser vanes is very advantageous in blowers with insufficient diffuser diameter and no spiral volute, the effect is not the same when, as in the case of Fig. 9, the supercharger tested has a spiral volute. Curves 1 to 4 show test results with different diffuser vane arrangements, while curve 5 refers to the same diffuser without vanes. It will be seen that the vaneless arrangement gives not only, as usual, a much flatter curve, but also better absolute values for the efficiency, which is not usual. This is explained, however, by the fact that the blower tested had a very narrow spiral volute. Apart from the test without vanes, it will be noted what a difference a properly adjusted set of vanes can effect on both efficiency and shape of the pressure curve.



Influence of diffuser vanes on low-efficiency radial engine supercharger.



Influence of diffuser vane arrangement on medium-efficiency supercharger with spiral volute. Curve 5 refers to a vaneless diffuser.

The effect of diffuser vane angles on a very efficient supercharger with web type impeller are shown in Fig. 10. The curves 1 to 5 correspond to different vane angles shown in

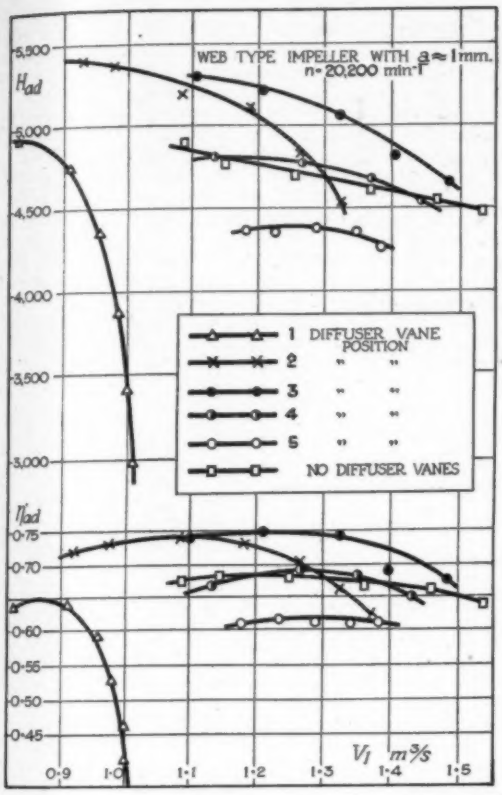
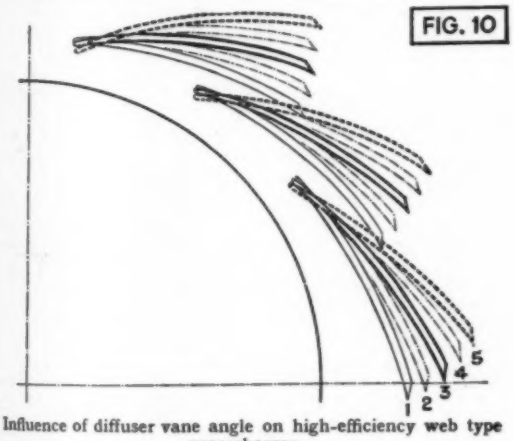
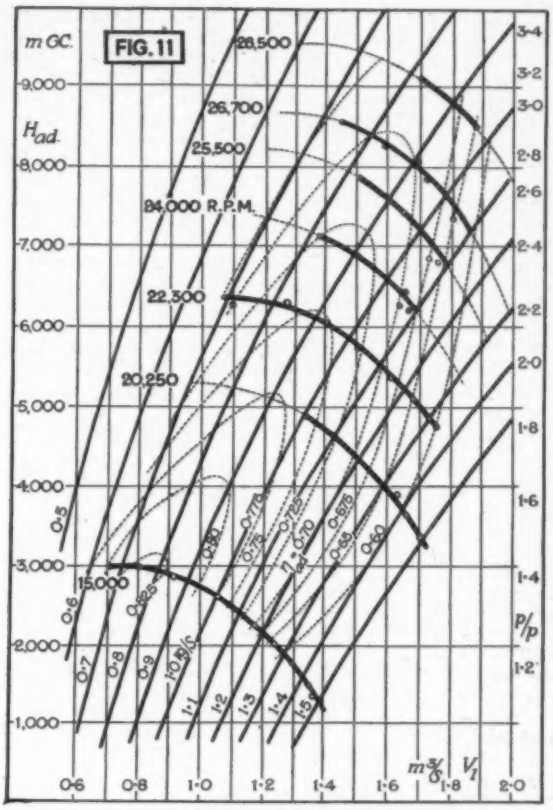


FIG. 10

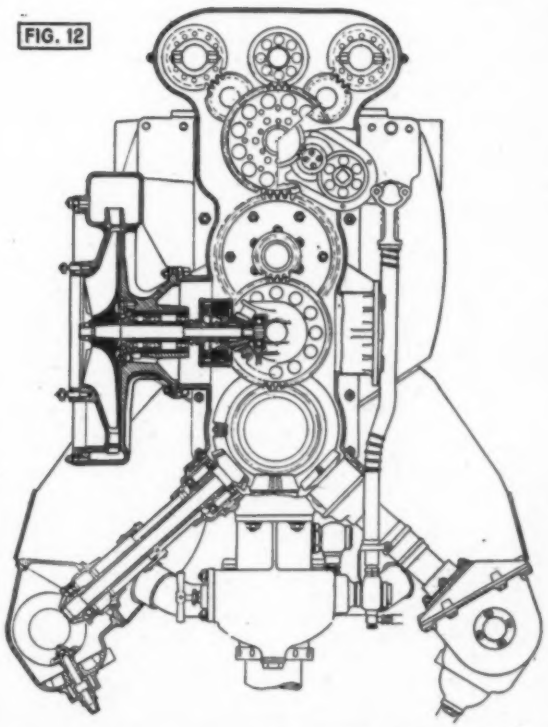


Influence of diffuser vane angle on high-efficiency web type supercharger.



Complete test curves of experimental DVL supercharger with closed-type impeller.

FIG. 12



Transverse supercharger on Daimler-Benz type 600 engine. The throttle is on the pressure side.

the bottom drawing, while the curves o (marked with little squares) show the results on the same diffuser without vanes. Medium vane angles are obviously best, the very detrimental effect of the very small angle 1 being particularly noticeable. Though in this case the vaneless arrangement shows a loss of both pressure and efficiency over the better vane angles, the extraordinary flatness of the pressure and efficiency curves are very noteworthy.

The effects of separate improvements in the inlet leads, impeller, diffuser vanes and spiral volute are to a large extent cumulative. The total effect of all these refinements is shown by Fig. 11, which gives the test curves of the experimental supercharger developed by the DVL, with closed impeller, inlet fan and the best diffuser vane and spiral arrangement. These curves show, beside the adiabatic pressure head H_{AD} the pressure ratio p_2/p_1. The curves at about right angles to the pressure curves show the flow

in kg. per second, while the dotted curves give the adiabatic efficiency. The p_2/p_1 and the weight flow curves are only valid for initial values of pressure and temperature corresponding to ground conditions.

The results obtained are certainly impressive, the very high maximum adiabatic efficiency of 82.5 per cent. at a pressure ratio of 1.4 and the maximum pressure ratio of over 3 with 65 per cent. efficiency being perhaps less important, though more showy, than the very good average efficiency over all the medium altitude field. These results show what a large margin for improvement there is in present-day standard engine superchargers, which do not come anywhere near the DVL figures. From what transpires from papers written by DVL men, this applies to Germany as well as to other countries. A glance at Fig. 12, showing the transverse supercharger fitted to the Daimler Benz 600 engine, indicates at once that the results cannot be any too good; the more so as, owing to lack of space, the throttle is on the pressure side. This is a very bad arrangement from the point of view of regulation, as, with varying altitudes, the supercharger is made to work right out of the good efficiency part of the curve.

The DVL results, good though they be, do not represent the ultimate practical possibility as regards efficiency. In the axial type compressors, developed for use with internal combustion turbines, *total* efficiencies of 82 per cent. are currently obtained, and it is hoped to reach at least 87 per cent. This implies adiabatic efficiencies of well over 90 per cent. The importance of a high adiabatic supercharger efficiency for aircraft engines cannot be over estimated; the decrease in engine inlet temperature allows a higher compression ratio to be used, and consequently higher MEP to be obtained. This applies to all types of aircraft engine, the air-cooled and petrol-injection types being particularly sensitive to low inlet temperatures, while the compression-ignition engine is much less affected. The figures given above show how much room there is for improvement in this direction.

TURBO-SUPERCHARGERS

Some Notes on Their Design and Construction

By F. UMPLEBY

THE problem of maintaining the sea level power output of the aeroplane engine at high altitude, in air of low density, cannot be too greatly stressed at a time when it becomes necessary to reach higher and yet higher altitudes with heavy loads. The present-day altitude records are all held by engines supercharged by means of exhaust-gas driven turbo-superchargers, and this is my reason for confining my attention to this type of supercharger.

The turbo-supercharger possesses the unique merit that it is operated by the exhaust gas energy of the engine, which energy is normally wasted. In addition, when the turbine is used to drive a centrifugal air compressor, the combination possesses yet another feature of considerable value in that the speed of the unit is not tied down to some proportionate engine speed, as is a gear-driven centrifugal compressor.

Taking normal sea level engine power output as a basis, we may well imagine the engine and the turbo-compressor to operate together in the form of a complete unit around a circle. If sea level atmospheric pressure be maintained in the induction side of the engine as the altitude increases, the engine will deliver a constant quantity of exhaust gas to the turbine; consequently the power output of the turbine will be constant.

However, as the altitude increases and the atmospheric pressure becomes lower, the resistance to the final discharge of the exhaust gas decreases. At the same time the weight of air entering the compressor also decreases; and as a result of these decreases in resistance, the speed of the unit driven by a constant quantity of exhaust gas increases. It increases until, if the machine were flying level at a higher altitude, a steady but higher turbo-supercharger speed is reached, which delivers the necessary quantity of air or mixture to the engine to maintain the engine at its sea level power output. (This statement will be qualified later on.) Of course, this phenomenon calls for a variable-pitch airscrew to keep the engine speed at its sea level rate, and the speed of the aeroplane would increase.

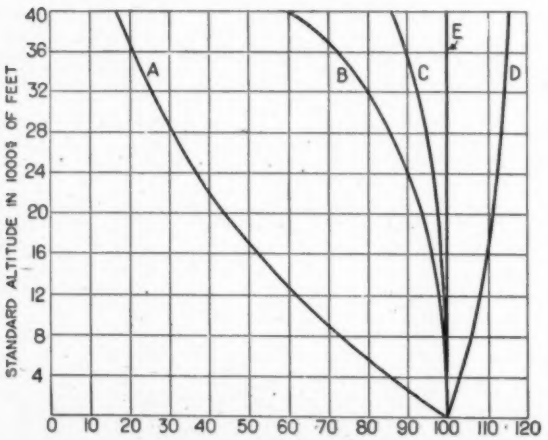


Fig. 1. **Power developed at different altitudes by a 100 h.p. engine fitted with various types of supercharger.**

This interaction between the engine and the turbo-supercharger persists until some altitude is reached at which the diameter of the air inlet reduces the quantity of air flowing into the compressor. In other words, the air is now throttled and the velocity at which the air must enter the compressor exceeds the power of the atmospheric pressure to overcome the depression created by the turbo-compressor and the ceiling is reached.

The theoretical effects of altitude on an engine of 100 sea level horse power unsupercharged, curve A, and supercharged, by different types of superchargers, are shown in Fig. 1 and from this it will be noted: That at 40,000ft. the power output with the Roots type, curve B, has fallen 40 per cent., with the gear-driven centrifugal or vane type 14 per cent., curve C, whilst with a turbo-supercharger capable of maintaining sea level atmospheric pressure up to 40,000ft., no loss in power is shown, curve E, but where the low density existing at 40,000ft. can be utilised on the engine and turbine exhaust side, as it can in my ballistic velocity turbine, the power output actually increases 14 per cent., curve D. This effect upon the exhaust is somewhat similar to the condenser vacuum effect upon the steam in a steam turbine.

The orthodox type of turbine used for turbo-supercharging is the "De Laval" impulse type of steam turbine constructed in heat resistant steel. In 1915 Prof. Rateau originated the exhaust-gas driven turbo-supercharger system of supercharging, and a lot of research work was carried out by the Allies along these lines. The mechanical troubles due to high speeds of the order of 30,000 r.p.m. and expansion of the nozzles, turbine wheel and casing due to high temperature, were overcome. But the deleterious effect of the high temperature exhaust gas upon the blades of the burbine, and the effect of the exhaust gas temperature combined with the back pressure upon exhaust valves and exhaust pipe work accompanied by decreased volumetric efficiency, still remained.

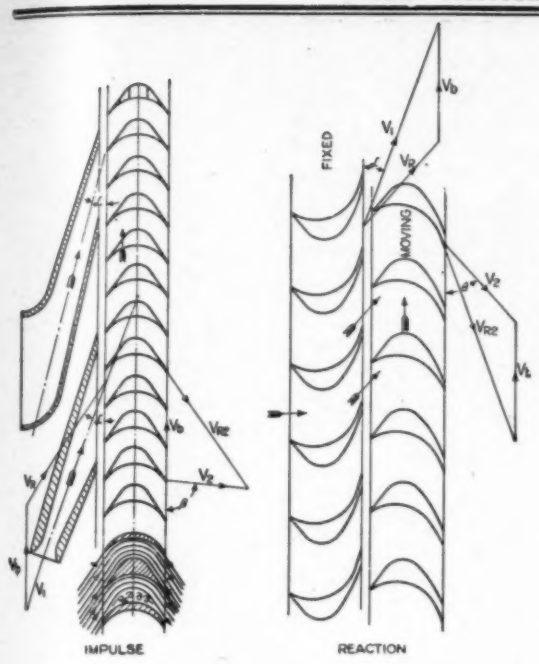


Fig. 2. Turbine blade and nozzle development and velocity diagrams.

During the interval between wars the heat resisting qualities of the steel used for the turbine wheel have been improved, but some form of cooling is still necessary. Sodium-filled exhaust valves can stand up to the high temperatures more successfully, but at the same time the compression ratio and engine speeds have increased with resultant increases in exhaust gas heat output, and the relative stage of development of the turbo-supercharger remains much the same.

Prior to discussing methods of cooling the turbine it would be as well to digress a little and discuss turbine construction and operation.

The steam or gas fluid driving the turbine enters the blades through nozzles such as are shown on the left-hand side of Fig. 2. If it be assumed that the entrance to the nozzle is situated in a region of high pressure, such as the exhaust pipe system of the engine, there will be a flow of fluid through the nozzle at a velocity of the order of the speed of sound to the region of low pressure at the nozzle outlet.

The lower nozzle shown in Fig. 2 is known as the convergent-divergent type of nozzle, and is usually used for single-stage impulse turbines of the "De Laval" or "Rateau" type, in which the pressure at the nozzle outlet is ·58 or less of the pressure at the nozzle inlet. This 42 per cent. pressure difference is the critical stage at which the flow of fluid along the nozzle becomes a maximum. The rate of flow under these conditions is calculated for and based upon the area of the throat where the convergent and divergent portions of the nozzle blend into one another.

The nozzle is not necessarily circular in section. Square or rectangular sections, provided the corners are well rounded, are equally efficient as nozzles and give superior results because they fill the turbine blades better than the circular nozzle, which only fills the blades at its radial centre line. Divergent nozzles should not have too much taper. If the taper exceeds 15 deg. inclusive angle the fluid tends to become turbulent in the nozzle and the efficiency falls off rapidly. When the final pressure is equal to or less than the critical pressure, and when adiabatic, frictionless flow is assumed, the area of the throat is calculated as follows:

$$A = \frac{144\,WV_s}{V_1} \text{ sq. in.}$$

where W = rate of fluid discharge in lb./sec.,
V_s = reciprocal of density of fluid at P_1 and T_1 in cu. ft./lb.,
P_1 = initial pressure of fluid, lb./sq. in. absolute,
V_1 = velocity of fluid, ft./sec.,
T_1 = temperature of fluid at P_1 in degrees F absolute.

V_s is calculated from $\frac{0{\cdot}37T_1}{P_1}$ cu. ft./lb.

This also gives V_s for air at various altitudes. V_1 is calculated from $72{\cdot}24\sqrt{P_1V_s}$.

In the convergent-divergent nozzle all the pressure energy of the fluid, or almost all of it, is converted into velocity energy, and the mass of fluid flowing together with its velocity are the source of the kinetic energy which drives the turbine, and this is given by:

$$K_E = \frac{WV_1^2}{2g} \text{ ft.-lb./sec.}$$

The efficiency of the nozzle, however, varies from 85 per cent. to 95 per cent., and $K_E = \frac{\cdot 9WV_1^2}{2g}$ is the amount of energy available for doing work.

Convergent nozzles such as the upper nozzle shown on Fig. 2 are used for multi-stage impulse turbines, where the pressure drop in the nozzle does not reach the critical pressure, some pressure remaining to be utilised in later stages of the turbine. Because of this the velocity of the fluid in the nozzle does not reach the high figures attained in the convergent-divergent nozzles. In multi-stage turbines the velocity of the turbine blades and the velocity of the fluid through the nozzles are generally about equal in value. The convergent nozzle is usually approximately square in section, its area being A = H × B, but since these nozzles, as well as the convergent-divergent nozzles, are usually arranged in series in line with the mean pitch diameter of the turbine blades with the jets impinging on the blades at an angle. The effective area per nozzle is:

$$A = \frac{P\sin\alpha - t}{P\sin\alpha}\, P\sin\alpha\, l.$$

For a series giving complete all round admission over the mean pitch circle of the jets and turbine blades, the total area is:

$$A_t = \pi D \left(\frac{P\sin\alpha - t}{P\sin\alpha}\right)\sin\alpha\, l$$

Here A = area of each nozzle in sq. in.; A_t = total area of a series of nozzles = $A \times n$; P = pitch of nozzles or veins in in.; α = nozzle angle in degrees; l = radial height of nozzle in in.; n = total number of jets; D = mean diameter of nozzle ring in in.; t = thickness of metal between jets.

This gives the nozzle area available. The area required to pass a given weight of fluid is given as before by $A = \frac{144\,WV_s}{V_1}$, but since the fluid is not fully expanded in the nozzle, V_s and V_1 must correspond to the conditions imposed by multi-stage design, and, since we are not interested in multi-stage design for turbo-supercharging we will not proceed further along these lines, even though this form of nozzle or blade is important in a turbine type still to be considered.

The multi-stage reaction turbine, the form of whose blades are shown on the right side of Fig. 2, is similar in many respects to the multi-stage impulse turbine. Here the stationary convergent nozzles are replaced by fixed blades in which the fluid gains velocity as it is partially expanded in the blade passages, but the jets generated impinge on the moving blades with less velocity than is the case in the impulse turbine. Further expansion occurs however in the moving blades, and a "carry over" velocity is generated whose direction of flow is changed in a second set of fixed blades, and the jets now impinge on a second set of moving blades, and so on, stage by stage, often exceeding twenty stages in a Parsons turbine. Here again we leave this type as we do not use the multi-stage turbine in the turbo-supercharger. It is the blade formation and design which is of interest.

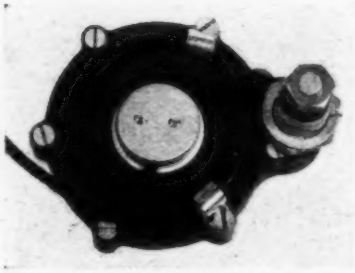
(To be continued.)

THE INDUSTRY

Korect Depth Gauge

IN these days of reliable engines, when it matters not one jot whether a course goes over desert, over sea, or over forest, what does matter is whether or not the petrol gauge is telling the truth.

The Korect Depth Gauge Co. in their fuel contents gauge have tackled this problem in a particularly ingenious and simple manner. Briefly, it is this. Fitted into the base of the tank is a metal bellows which is connected to the dashboard instrument by a capillary tube and this capillary tube terminates in a metal capsule, the breathing of which operates a conventional crank-cum-rack and pinion pointer mechanism. The whole system is charged at a slight positive pressure with dry nitrogen gas, as this gas is least affected by changes in temperature. It is obvious that the weight of the contents of the tank will compress the metal bellows and that this pressure will be transmitted through the capillary tube to actuate the instrument mechanism. So much for the simplicity of the idea, the refinements are many and one of the main advantages is that no petrol is brought into the cockpit. Since it is the column of fuel immediately above the tank fitting which is weighed so to speak, the shape of the tank has to be taken into consideration and the graduated scale is calibrated against an accurate dipstick. For ease of fitting, and to obviate heavy loadings due to aerobatics, the metal bellows are enclosed in a membrane box which is situated *outside* the tank and connected to the contents by a hollow bolt, the holes in which are small enough to slow up the change of pressures. Incorporated in the hollow bolt, also, is a ball valve which automatically stops the flow of petrol if the instrument is removed for inspection. The capillary tube requiring a slight amount of time to pass the varying pressures it acts rather in the manner of a dashpot and ensures a steady reading on the dial, all surge being damped out completely. This feature is particularly useful when the gauge is used, as they are to some considerable extent, on high speed motor boats where surge is a severe problem.



The membrane box of the K.D.G. fuel contents gauge, showing the hollow bolt fitting and part of the capillary tube.

In addition to fuel contents gauges, K.D.G. also make fuel pumps, suction gauges, and pressure gauges, as well as rate of climb and airspeed indicators.

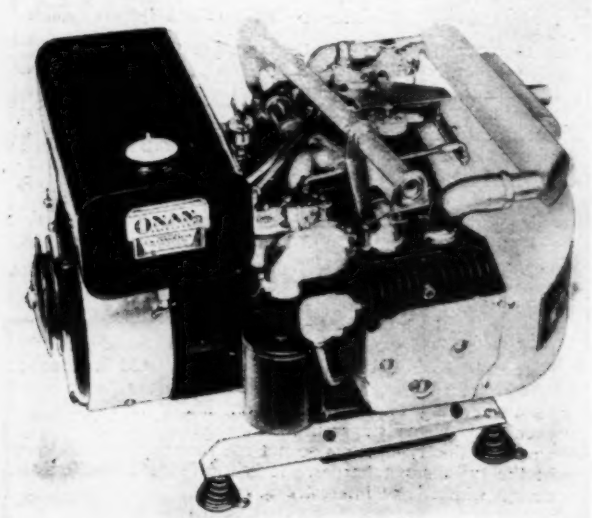
Portable Power

FOR round about 100lb. weight and such small dimensions as 24in. by 17¾in. by 15¼in., the various models of Onan electric power plants have capacities ranging from 1,500 to 2,000 watts.

They have been designed primarily for aircraft service, but their extreme light weight and compact construction make them adaptable for many and varied purposes, such as radio stations, portable X-rays, floodlights, medical and dental clinics in the field and a host of other uses where a supply of electric current is a necessity.

The engine is an air-cooled, horizontally opposed, two-cylinder, four-stroke petrol engine, developing 3.7 horse-power at 2,850 r.p.m. Ignition is from a flywheel magneto.

No less than twenty-one different types of generators and control systems are available. They include D.C. types from 12 to 230 volts, A.C. types of 115 and 230 volts and A.C.-D.C. types covering the same range. All models can be supplied with self-cranking windings to allow of remote control or fully automatic starting of the unit. Particulars are to be had from B.M.B. Engineering Co., Ltd., Britannia House, Ampton Street, W.C.1.



Compactness is a feature of all the Onan electric power plants. The illustration also shows the disposition of the various units and the sprung mounting.

Hose Clips

LITTLE things can be of importance. Here is a hose-clip that is widely used for safety in oil, water, petrol or air joints. The special feature of the "A.A." hose-clip which, incidentally, is approved by the Air Ministry, is that the tension band passes twice round the hose so that the centripetal pressure due to band tension operates at every point, even at the "gap," under the tightening screw. To effect this the tape is split for a certain length so that it can pass through itself to complete a second circle.

Size diameters are standardised progressively in inches, 1in., 2in., 3in., etc., and adjustability between sizes is available by selecting any appropriate hole in the punched tape. The slow thread and double purchase given by the "twice round" principle enables very considerable tension to be obtained with small effort at the screw head.

In a new type, to be known as "B.B.," just coming on the market, a link avoids the necessity of splitting the tape and has enabled the overall width to be reduced. Length adjustment is easily made by simply folding back the tape at the link and the absence of holes in the tape increases its strength. The clip will easily withstand any reasonable working pressures for any purpose.

The new "B.B." Linolite hose clip.

It is manufactured by Linolite, Ltd., 100, Victoria St., S.W.1.

PUBLICATIONS RECEIVED

National Advisory Committee for Aeronautics: Report No. 665: Calculation of the Aerodynamic Characteristics of Tapered Wings with Partial-Span Flaps, by H. A. Pearson and R. F. Anderson; 10 cents. No. 669: Airfoil Section Data Obtained in the N.A.C.A. Variable-Density Tunnel as affected by Support Interference and Other Corrections, by E. N. Jacobs and I. H. Abbott; 10 cents. No. 673: Experimental Verification of the Theory of Oscillating Airfoils, by A. Silverstein and U. T. Joyner; 10 cents. No. 674: Cooling on the Front of an Air-cooled Engine Cylinder in a Conventional Engine Cowling, by M. J. Brevoort and U. T. Joyner; 10 cents. No. 675: Effects of Elevator Nose Shape, Gap, Balance, and Tabs on the Aerodynamic Characteristics of a Horizontal Tail Surface, by H. J. Goett and J. P. Reeder; 10 cents. No. 678: Interference of Tail Surfaces and Wing and Fuselage from Tests of 17 combinations in the N.A.C.A. Variable-Density Tunnel, by A. Sherman; 10 cents.

Twenty-fifth Annual Report of the National Advisory Committee for Aeronautics, 1939; 20 cents. Superintendent of Documents, Washington, D.C., U.S.A.

How the Air Force Defends Us, by Maj. C. C. Turner; 5s., George Allen and Unwin, Ltd., Ruskin House, 40, Museum Street, London, W.C.1.

An Old Captivity, by Nevil Shute; 8s. 6d., William Heinemann, Ltd., 99, Great Russell Street, London, W.C.1.

Forecasting Weather, by Sir Napier Shaw, third edition; £2 2s., Constable and Co., Ltd., 10, Orange Street, London, W.C.2.

Airplane Design Manual, by F. K. Teichmann; 18s., Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, London, W.C.2.

Electricity in Aircraft, by W. E. Crook; 5s., Sir Isaac Pitman and Sons, Ltd.

Electrical and Wireless Equipment of Aircraft, by S. G. Wybrow; 5s., fourth edition, Sir Isaac Pitman and Sons, Ltd.

Air Chevrons, by Simpson Fraser; 6s., Arthur H. Stockwell, Ltd., 29, Ludgate Hill, London, E.C.4.